TWO SECTIONS SECTION 1

S·A·E JOURNAL

SUMMER MEETING

JULY ★ ★ ★ 1931

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PRESIDENT

S·A·E· JOURNAL

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The purpose of meetings of the Society is largely to provide a forum for the presentation of straightforward and frank discussion. Discussion of this kind is encouraged. However, owing to the nature of the Society as an organization, it cannot be responsible for statements or opinions advanced in papers or in discussions at its meetings. The Constitution of the Society has long contained a provision to this effect.

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S·A·E JOURNAL

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Engineering Progress Awakes Enthusiasm

Forward-Looking Papers Draw Good Attendance at Summer Meeting Sessions—Ideal Setting and Weather for Sports

FINE WEATHER, a lovely setting in the Alleghany Mountains of West Virginia, a golf course and grounds that are beautiful by nature and art, faultless and unobtrusive service in the hotel, earnest and well-attended technical sessions and the usual pleasures of good fellowship and sports characterized the Semi-Annual Meeting, held at the Greenbrier Hotel, White Sulphur Springs, W. Va., June 14 to 19.

Nearly everyone present seemed to be enjoying the golf, and attendance at the various technical sessions seemed to be decidedly better, on the whole, than at other recent Summer Meetings. A count of those attending the various sessions showed a total of 1450.

Certainly the attendance was remarkably good for "this year 1931, of the Great Depression," as the time was described by one of the speakers. The difference from normal attendance was not perceptible to the naked eye. Evidently virtually all of the members who came to take part in the committee meetings and main activities were found in their places as usual. Possibly one of the reasons for the good attendance at the technical sessions was that no tournament golf was played during the mornings.

Past-Presidents of the Society who attended the meeting, were as follows: H. W. Alden, David Beecroft, B. B. Bachman, H. L. Horning, T. J. Litle, Jr., J. H. Hunt, W. G. Wall and Edward P. Warner.

High spots of the meeting were the evening sessions held Tuesday and Thursday, at both of which the subjects were such as might appeal specifically to the engineers and to their families as well. Driving Cars at High Speed, Mr. Hale's theme of Wednesday night, is a subject that appeals to all, and it was handled in a way which suggested new responsibilities to the automobile engineer.

Showmanship in a Presentation

With the second paper of the evening, the team of Walt & Walt, Keys & Fishleigh, went into action with such effect that one Detroit member, who might have been a little sleepy, dreamed that he was back in 1918, when Walter T. Fishleigh was cheer lea—no, chairman—of the Section which was then passing Metropolitan in membership. The former Michigan professor and Ford executive engineer was introduced by Mr. Keys as an apple-pie engineer, half apple sauce and half crust, and was presented with potted onion sprouts, a mammoth Bermuda onion and a knife, and a red bandana, to assist him in presenting The Tear-Drop Car. The audience also was supplied with weeping-towels. However, all these properties proved useless, and Mr. Fishleigh was complimented by many for his enterprise in exploring a promising design that is far removed from the conventional.

Past-President Harry Horning, whose paper on Why Engineers Leave Home was given at the Thursday evening session, is one of the most popular speakers in the Society and presented a story of real human interest.

The Field Day sports were highly amusing, and one of the events not regularly scheduled under the Aviation Demonstrations proved to be of unusual interest. This was a double event on Thursday afternoon, consisting of an explanation of the working of the Autogiro, given by A. E. Larson, and exceptionally clear and significant talking pictures showing the functioning of details of the mechanism as well as demonstrations of flying, landing and taking off. In the presence of a head wind, the machine was shown hovering and flying backward. This picture was followed by a demonstration at the Greenbrier Airport, in which an Autogiro landed and took off several times and hovered at what seemed from the ground to be little faster than a walking speed.

One item of equipment which contributed to the success of the sessions held in the Auditorium was a new type of microphone, made by the Western Electric Co. It is said that only five microphones of this type exist, three of which were at the meeting for the use of the chairmen and speakers. The apparatus was contained in a small button worn like a gardenia, so that it followed the speaker wherever he turned. Each button was provided with a short wire and connector by means of which it was coupled to the amplifier. Making and breaking this

connection once or twice was found by some of the chairmen to be a real labor-saving device in the form of an electrical gavel.

The Society is indebted in large measure to Edward G. Budd, president of the Edward G. Budd Mfg. Co. and of the Budd Wheel Corp., of Philadelphia, and a Member of the Society, for having made possible the publication of the *Daily SAE* during the Summer Meeting. H. A. Coward was publisher of this bright and enlivening newspaper, and Griscom Bettle was editor. The designated reporters from the Young & Rubicam Advertising Agency in New York City were Henry Wood, William H. Jenkins and Sydney Ward. Their successful efforts in collecting news and devising features were supplemented by members of the S.A.E. Staff and others. The consensus of opinion was that these issues of the *Daily SAE* constitute one of the best series of this perennial that has ever been produced.

Splendid cooperation was accorded the Society by the *Automotive Daily News*, which reported the daily sessions and events and printed extensive summaries of the papers in the daily editions distributed at the hotel; and also by the weekly trade journals in advance of and during and following the week's meeting.

CALENDAR

National Meetings

20th National Aeronautic Meeting—Sept. 1 to 3
Hotel Statler, Cleveland
In conjunction with the National Air Races

Production Meeting—Oct. 7 an 8
Book-Cadillac Hotel, Detroit

Transportation Meeting—Oct. 27 to 29
City of Washington

Analytics Applied to Trucks

Rating Formula Prescribed—Capability-Measurement Unit Advocated at Opening Session

MOTOR-TRUCK ratings and capabilities were analyzed at the opening Session held Sunday evening, June 14, under the chairmanship of H. W. Alden. M. L. Pulcher discussed motor-truck ratings, and the second paper, presented by L. R. Buckendale, advocated a unit of rating by which inherent truck capability can be measured.

Why Not Do Something About It?

Paraphrasing Mark Twain's comment on the weather, to the effect that many talk about it but nobody does anything about it, Mr. Pulcher remarked that, although motor-truck-industry representatives have long sought a practical truck-rating method that would approximate truck performance, virtually no definite result has yet been accomplished. Wide variations in truck specifications for the same tonnages exist; chassis vary in weight from 2400 to 5300 lb. in the 1½-ton, 2925 to 6800 lb. in the 2-ton, 4500 to 8500 lb. in the 3-ton, and 5800 to 11,300 lb. in the 5-ton groups. He said that a decision should first be made as to what a rating formula is to represent, and discussed three angles of approach: (*a*) a conservative rating, whereby both manufacturer and customer agree that the vehicle is capable of carrying a considerable overload; (*b*) a maximum rating, representing all that the vehicle will carry safely under average conditions; and (*c*) the abolition of ratings entirely and substitution of the maximum gross allowable weight.

Mr. Pulcher analyzed the factors involved in truck ratings and discussed possible formulas for satisfactory rating. In conclusion he said that, although formulas give only approximations, even these are infinitely better than nothing. Their purpose is to provide a simple, practical method of appraising truck capacities that can be understood and used by manufacturers, truck dealers, salesmen and operators.

Truck-Ability Unit of Measurement

Engine power must be one of the elements of the rating unit used to measure the inherent ability of trucks, said Mr. Buckendale in his paper. Gear reduction from the engine to the rear-

MEMBERS AND GUESTS WATCHING FIELD DAY SPORTS AND TAKING PART IN CHEF-BOXING EVENT

CHAIRMAN AND AUTHORS OF PAPERS AT TRUCK AND COACH SESSION

Past-President H. W. Alden, Chairman of Session; M. L. Pulcher, of the Federal Motor Truck Co., and L. R. Buckendale, of the Timken-Detroit Axle Co., Who Proposed Bases of Rating the Ability of Motor-Trucks

axle shaft and effective radius or leverage of the wheels themselves are two other essential elements, and over-all mechanical efficiency is another. The foregoing determine motor-truck ability to move a gross weight under given conditions, and these include other factors such as the road gradients, rolling resistance and wind resistance. In conclusion, after presenting various formulas for determining the foregoing factors, Mr. Buckendale proposed that trucks be rated by the gross vehicle-weight that can be hauled up standard grades and suggested as gradients (*a*) 4 per cent, in tractor and trailer service; (*b*) 5 per cent, favorable service; (*c*) 6 per cent, average service; and (*d*) 7 per cent, heavy-duty service. He recommended the requirement of 85 per cent efficiency and 0.015 lb. per lb. of gross vehicle-weight as the rolling resistance.

Truck-Rating Problem Unsettled

In the general discussion of both papers, Pierre Schon criticized the three methods suggested by Mr. Pulcher and said that he believes the maximum gross rating is the best. A. J. Scaife suggested consideration of a formula having as a basis gross load in relation to chassis weight, ability as expressed in pound-feet of torque, and fixed speed in miles per hour as a constant. B. B. Bachman proposed (*a*) that the gross vehicle-weight be determined by using a gradient factor of 3 per cent in direct gear; (*b*) that factor (*a*) be used for all types of hauling; (*c*) that engine speed be kept within definite limits; and (*d*) that, for dump service and tractors, the gears, bearings and structural load-carrying portions of the chassis be compared on the basis of continuous operation in next to top gear. M. C. Horine analyzed some of the assumptions made by the authors before discussing the conclusions they reached, and said that the real clue to the situation lies in the pneumatic tire, amplifying this statement afterward.

J. F. Winchester said in part that the motor-truck industry should have decided upon a suitable rating method long ago. At present, he remarked, a distinct tendency exists on the part of legislators to legislate against motor-truck usage because many abuses have been brought about by oversale of trucks. This has resulted in serious accidents and many deaths and created a feeling among individuals of the general public that vehicles of this type are not safe to operate.

F. K. Glynn introduced the following motion that was, after debate, voted upon and carried and scheduled for presentation to the S.A.E. Council:

It is the sense of this meeting that the subject of truck rating is of such importance that a solution must be sought, and it is therefore recommended that the Motorcoach and Motor-Truck Activity Committee, together with the Transportation and Maintenance Committee, form a joint committee to study truck rating with the view of bringing forth some generally acceptable method of rating motor-truck and motor-coach chassis.

At a subsequent meeting of the Council, the proposal to form a joint committee to study truck rating was approved.

Two Diesel-Engine Problems

Fuel-Rating Study and Torsional-Vibration Dampers Occupy Diesel-Engine Session

OPENING the Monday morning session as Vice-President of the Society for Diesel Engines, W. F. Joachim, mechanical engineer, of Philadelphia, and a specialist on Diesel engines, gave a brief review of the history of fuel-oil research which has led to the cooperative effort of the American Society of Mechanical Engineers and the S.A.E. in a joint committee of which W. H. Butler is secretary.

Fuels for Automotive Diesel Engines was the subject of the first paper, by Mr. Butler, technologist of the Standard Oil Co. of New Jersey, who explained that his assignment was to cover the fundamentals as a groundwork for discussion. Automotive Diesel engines have different fuel requirements than do large slow-speed Diesel engines; the combustion-chambers and injection mechanisms of the two classes of engine must be different also, and Mr. Butler believes that engine designers have made more progress in these details than have oil producers in developing the needed fuels.

Various theories are advanced for detonation in Diesel engines, which is said to differ basically from detonation in gasoline engines. The author supports the theory that ignition lag is the cause. If the lag is sufficient, the full charge of fuel may be injected before ignition occurs, and the burning may then be undesirably rapid. High compression was said to eliminate detonation, and preheating the air to give the same compression temperature was suggested. A catalyst or ignition oil might also provide a satisfactory solution. Producing an oil that will ignite quickly and burn slowly sounds difficult, but such an oil has been produced experimentally.

Dependence cannot be placed upon distillation tests at atmospheric pressure; it is necessary, said Mr. Butler, to distill the oil in a vacuum, which prevents cracking during the process and gives reliable results. Curves were given to show the discrepancies between the results of atmospheric and vacuum distillation. A formula is used to interpret various chemical and physical properties of oil into terms of suitability for the automotive Diesel engine.

Many oils contain a trace of naphthenic acid. Mr. Butler said that this is not detrimental to metallic surfaces and its removal involves considerable expense. The same is true of gum in its effect upon Diesel engines, in which it does not cause the same difficulty as

PRINCIPAL PARTICIPANTS IN THE DIESEL-ENGINE SESSION

W. H. Butler, of the Standard Oil Co., Whose Subject Was Automotive Diesel Fuels; W. F. Joachim, Mechanical Engineer, of Philadelphia, Chairman; and Erich Sandner, of Germany, Co-Author with J. B. Frauenfelder, of Philadelphia, of a Paper on Devices for Damping Torsional Vibrations

in gasoline engines. Sulphur was said not to be important in large engines but to have an effect on the automotive Diesel, particularly if the engine is used intermittently. Viscosity and lubricating quality are important in their relation to injection mechanisms, to seal the plungers and valves against leakage and prevent excessive wear.

Economics Should Influence Fuel Specification

Comparing the small Diesel engine of today with the gasoline engine of a quarter century ago, A. Ludlow Clayden, of the Sun Oil Co., warned against establishing fuel specifications that might interfere with the logical and economic development of the engine. A straight-run paraffin-base oil may be the best fuel available now, but more and more cracked gas-oil is being produced, and fuel cost gives an incentive to develop engines that will utilize this fuel. Light gas-oil would be more expensive than gasoline if the demand for it were to increase too rapidly. The demand for lubricating value in fuel for the sake of the fuel-pump was characterized by Mr. Clayden as an admission that we do not know how to make pumps.

Viscosity and vapor-locking, which affect getting oil into the engine, and surface tension and ignition temperature, which influence its burning, were cited by Dr. O. C. Bridgeman, of the Bureau of Standards, as problems that demand research and are still more fundamental than those discussed in Mr. Butler's paper. The true ignition temperature is in the liquid and is not now being found in tests. Dr. A. G. Haskell, of the Texas Co., said that the important point may be that of partial, not complete, ignition.

Dr. George W. Lewis reported promising results by the National Advisory Committee for Aeronautics in photographing combustion and developing an aircraft fuel with little regard to cost, and said that engines are not available for the two big airships now being built and one more in prospect. Other discussers were R. J. Broege and Dr. H. C. Dickinson.

Erich Sandner, who contributed much of the material for the paper on Experiences with Devices for Damping Torsional Vibrations, is a consulting engineer in Dortmund, Germany, and is said to have solved problems of this sort for several of the leading naval powers of the world, for both naval and aeronautic engines. J. Barraja-Frauenfelder, a Philadelphia consulting engineer, was the co-author and read the paper.

Mysterious Shaft Breakages Solved

Torsional vibration, according to the authors, began to be recognized as a cause of otherwise unexplained fractures of Diesel-engine shafts near the beginning of the present century. Analytical investigation of the subject was forced, shortly before the World War, by difficulties with submarine Diesel engines, which troubles often were ascribed to faulty material or lightness of design. Only a few outstanding specialists then understood the complex subject of synchronous vibrations and were able to make the calculations necessary for predicting and avoiding them.

After classifying vibration dampers, descriptions were given of devices of various types and their usefulness was evaluated. A stiff quill connecting-shaft was compared with a flywheel at the free end of the shaft, each manually connected by clutches. The quill shaft raises the frequency and the extra flywheel lowers it, the latter having advantages in lower weight and cost.

Hydraulic throttling dampers, of a type developed by Junkers for aeronautic engines, were said to be very effective if a reduction in vibration amplitude of only 50 per cent is sufficient. Mechanical friction dampers have a somewhat different effect, as they connect the damping flywheel rigidly with the shaft, up to a certain point. The friction dampers are said to be the more effective for moderate-sized engines when their adjustments are suited to the vibration, but they should be used only as a safety device on larger engines because of friction and wear.

The final type of damper described is one in which hydraulic friction is substituted for mechanical friction. A combination of internal gear and several pinions forms a multiple gear-pump which forces oil from the lubrication system past a relief valve that provides a constant friction. The effect was said to be the same as that of the mechanical friction device, but the heat is carried away by the oil and the adjustment is not changed by wear. This device and several of the others mentioned were illustrated by drawings and photographs, and the results of tests were indicated by charts.

Story of the Graf Breakage

Written discussion of the Sandner and Frauenfelder paper was presented by J. Ormondroyd, of Westinghouse, who explained that lubricating the friction surfaces of the Lanchester-type damper has reduced variations in friction coefficient at the expense only of heavier spring pressure; and by George

Nominees for Offices for 1932

For President—Arthur J. Scaife

For Vice Presidents—

- **William B. Stout, Representing Aircraft Engineering**
- **Charles L. Lawrance, Representing Aircraft-Engine Engineering**
- **Alfred J. Poole, Representing Diesel-Engine Engineering**
- **B. B. Bachman, Representing Motor-Truck and Motorcoach Engineering**
- **Delmar G. Roos, Representing Passenger-Car Engineering**
- **Adrian J. Neerken, Representing Passenger-Car-Body Engineering**
- **A. S. McArthur, Representing Transportation and Maintenance Engineering**
- **J. E. Padgett, Representing Production Engineering**

For Treasurer—C. W. Spicer

For Councilors, to serve through 1932 and 1933—

- **H. T. Woolson, R. E. Wilson and S. O. White**

J. Dashefsky, vibration expert at the Navy Yard in Brooklyn, who stated that the best plan is to make the design such that no damper or a synchronizing device is needed, sometimes at the expense of one critical speed within the operating range of the engine.

Crankshaft breakages on the Graf Zeppelin, which excited so much comment in the spring of 1930, were alluded to at first vaguely by the author and the Chairman and then explained. Mr. Frauenfelder said that the coefficient of friction in the Lanchester dampers changed and some springs broke. When the springs were replaced with spares on board, someone thought that they were not stiff enough and inserted thicker washers, thus increasing the friction and altering the action so that the crankshafts snapped, one after another.

Motorcoach and Truck Utilization

City Coaches and Motor-Trucks as Work Units Studied at Transportation Session

ANALYSES of the utilization of motorcoaches and motor-trucks were presented at the Transportation Session held Monday morning, June 15, under the chairmanship of F. K. Glynn. Motorcoach utilization was discussed by D. A. Smith, and motor-truck utilization was treated by A. H. Gossard, through the cooperation, respectively, of the American Electric Railway Association and the National Electric Light Association.

Desirable Motorcoach Types

Perhaps the localized conditions under which the coach is to be operated constitute the most important factor in determining the most suitable type of motorcoach, said Mr. Smith, of the Detroit Street Railways. In fact, he continued, since the very inception of the motorcoach, the demand for a coach to provide specific services under varying topographical and climatic conditions has severely taxed the research and designing staffs of both the manufacturer and the carrier. He believes that the motorcoach has and will continue to have a definite place in the scheme of city transportation and, except for a few main trunk lines in some of the larger cities, it has proved its greatest usefulness to the street-railway industry in making possible the provision of transportation in territories between and beyond existing car lines where service had become a paramount necessity but could not be provided by trolley-car because of the high cost of right-of-ways, overhead and feeder construction, without the acceptance of a most definite operating loss. Continuing, Mr. Smith discussed in some detail trolley-coach advantages, desirable factors concerning motorcoach bodies and frames, suitable powerplants and transmissions, and details concerning steering mechanisms.

In the discussion, F. C. Horner, of the General Motors Corp., expressed his opinion that the designing engineers are doing everything they can to improve both the motorcoach and the motor-truck as regards design, materials and construction, with the one possible exception that he notices no great improvement in reducing weight. An important point is that the engineers should strive to meet the reasonable requirements of the operator.

A. S. McArthur, of the Toronto Transportation Commission, remarked Mr. Smith's mention of the 21 to 23-passenger and the 40-passenger sizes and said that the latter size could not be used in Toronto, which is a comparatively small city. Instead, the second size used there is of 27 to 29-passenger capacity. B. J. Lemon, H. C. Eddy and others offered discussion.

Motor-Truck Utilization

Mr. Gossard, of the Middle West Utilities Co., treated the motor-truck as a work unit, his purpose being to measure its utility by the amount of work it performs and to deal with it more as a transport unit than as a portable power-unit. The utilization of motor-trucks in the public-utility field, as it applies to some 200 electric, gas, ice, water, coal and railway enterprises, was analyzed. The speaker said that the principles of efficient operation as applied to motor-trucks in the utility field are: Standards of performance, records, planning, routing, scheduling, dispatching, and standardizing conditions and operations. The feeling is, he continued, that the performance standards will not be the same for large companies in large cities and for companies that spread over a large territory and serve many small communities; however, these companies can set up their own standards of performance by keeping records.

The standardizing of conditions and operations can be applied to any operation of motor-trucks, Mr. Gossard remarked, but it is questionable how far these principles can be applied. The use of motor-trucks in industry is still comparatively new, and many factors that are not yet settled affect the use of trucks. "Hired" or contract service, where its use is justified, is recommended to all. Specialized equipment should be avoided, especially where it definitely limits the motor-truck to one job, asserted Mr. Gossard, who said that specialized jobs can be taken care of by a combination of standard and specialized units, which will readily lend the combination to change so that, if it is necessary for a different type of work to be done, at least one or more of the units can be used. Standardized cab-to-axle dimensions, frame widths, fifth wheels and trailer-frame dimensions will assist operators in applying some of the principles.

Mr. Horner remarked in the discussion that Mr. Gossard increased the number of trucks and of miles traveled with only a 5 per cent increase in cost, and he cited this as a good illustration of what scientific management can accomplish. Adrian Hughes, of the

THOSE WHO TOOK CHIEF PARTS IN THE TRANSPORTATION SESSION

D. A. Smith, of the Detroit Department of Street Railways, Whose Subject Was the Utilization of Motorcoaches; F. K. Glynn, of the American Telephone & Telegraph Co., Chairman; and A. H. Gossard, of the Middle West Utilities Co., Who Spoke on Utilization of Motor-Trucks

United Railways & Electric Co. of Baltimore, said that the paper proves the necessity for keeping suitable records and making accurate cost analyses. The subjects of the pooling of vehicles and handling them by unit-dispatching methods, how to eliminate gas fumes and noise, and similar pertinent topics related to the general subject of utilization were discussed also.

Fuel Research Renders Account

Apparatus, Methods and Results Presented—Bureau of Standards Workers in Leading Rôles

DR. H. C. DICKINSON sat beaming to the front in the second row of seats at the Fuel session. If he had been chairman in place of A. L. Beall, of the Vacuum Oil Co., it would have been an All-Bureau session. To be sure, the first paper was presented by C. S. Kegerreis, who is a consulting engineer in Toledo, but he has had much contact with the Bureau of Standards.

Mr. Kegerreis told of Carbureter Design for the Fuel-Research Detonation Engine, which presents a much more difficult problem in some respects than the design of a commercial carbureter. A variation of only 2 to 3 per cent is permissible in the mixture, instead of 5 to 8 per cent which is allowable from the commercial carbureter; and a single-cylinder engine presents a different problem for the mixture-producing apparatus than does a multi-cylinder engine. Thorough mixing of the fuel and air is needed so that all combustion strokes shall have as nearly as possible the same detonation value, and the necessity for accuracy of a sort that will make it possible to duplicate tests must be constantly borne in mind.

The construction described, known as the Dobbs carbureter, originated in the laboratories of the Anglo-American Oil Co. Two or three successive models have been steps in the development of the design. An air-bleed has been found more suitable than a needle-valve for regulating the gasoline, and a cylindrical throttle is an improvement upon the butterfly-valve for the air. Two float-bowls are provided to make two separate carbureters having common air and fuel channel, mixture passageway and throttle. This type is used with the Horning engine for research installations in which only two types of fuel are used. Four bowls are provided for the routine-test type. The air and fuel are turned on or off by a single operation.

Mr. Kegerreis reported that these carbureters have an adjustment range of two turns, in place of the fraction of a turn usually required with needle-valves. The actual value of the minimum-detonation point usually checks within three points on the gas scale; and the knock-meter readings should usually check to a closer value, particularly near to the 50-per cent region on the meter scale.

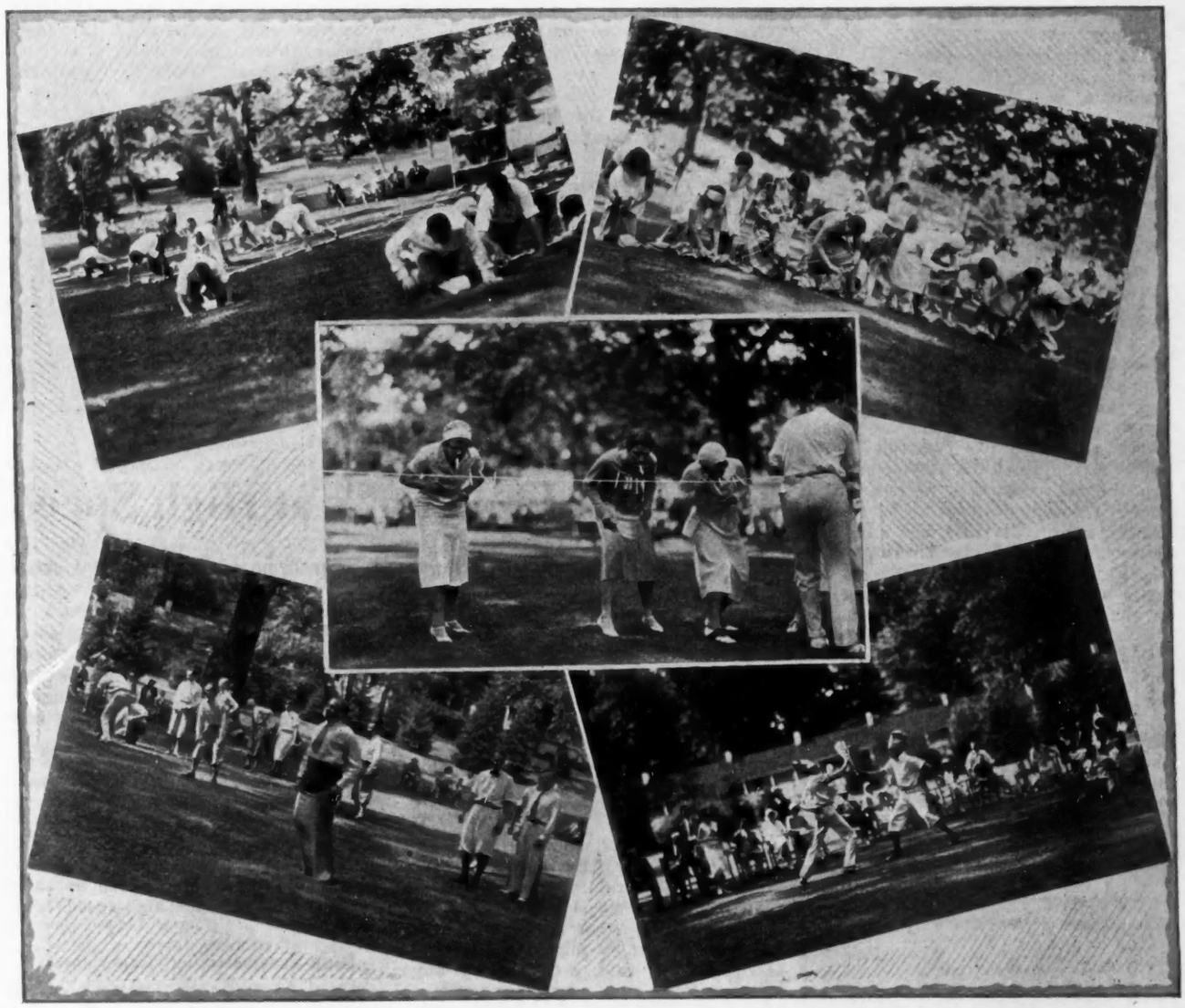
Service on carbureters supplied to distant points is facilitated by using parts, such as screws, floats and needles, that can be purchased from a manufacturer having service stations in the more important countries.

Production-Line Fuel-Test Methods

Donald B. Brooks led the way for the Bureau with his paper on the Interpolation Method in Detonation Testing. A gasoline is tested by burning it in a high-compression test-engine and finding a throttle setting that will cause moderate detonation as measured in gas evolution by the bouncing-pin. Two reference fuels are selected of known octane rating, one

CHAIRMAN AND AUTHORS OF PAPERS GIVEN AT THE SESSION ON FUELS

(1) A. L. Beall, of the Vacuum Oil Co., Chairman; (2) C. S. Kegerreis, of Toledo, Who Told of Carbureter Design for the Fuel-Research Detonation Engine; (3) Dr. O. C. Bridgeman and (4) Miss Elizabeth W. Aldrich, Who Reported Further Developments in Determining Gum in Gasoline; (5) Donald B. Brooks, of the Bureau of Standards, Who Spoke on the Interpolation Method in Detonation Testing; and (6) H. S. White, of the Bureau of Standards, Co-Author with Dr. Bridgeman of a Paper on Fuel-Line Temperatures as Measured in Motor-Cars of 1931 Model.



SOME OF THE FIELD-DAY EVENTS THAT CREATED GREAT MIRTH ON WEDNESDAY AFTERNOON

(Upper Left) Roly-Poly Race. (Upper Right) Kid-Boots Derby. (Center) Clothes-Pin Race. (Lower Left) Sack Relay Race. (Lower Right) Chef Boxing

higher and the other lower than the fuel under test, and the octane number of the sample is interpolated according to the gas-evolution reading.

Most eastern gasolines have octane ratings between 55 and 75. If the carbureter described by Mr. Kegerreis has three of its bowls fed with 55, 65 and 75-octane reference-fuels and the fourth with the sample, any fuel within these extremes can be rated without changing reference fuels. The precision of the rating depends in part upon how nearly direct is the proportion between octane rating and gas evolution. If the proportion is represented by a straight line, it makes no difference how far separated the reference fuels are on the scale; if by a curved line, the precision is greater if the reference fuels are near together.

Mr. Brooks stated that a degree of precision commensurate with that of other observations can be attained, with proper adjustments, from reference fuels separated by 10 octane numbers, and supported the statement with charts and tables. Further testing is required to demonstrate general application.

Discussion of these two papers was deferred to the meeting of the Detonation Subcommittee held on Tuesday.

Gum-Determination Developments

When Elizabeth W. Aldrich, of the Bureau of Standards, came to the platform to read the paper on Developments in the Determination of Gum in Gasoline, prepared by herself and Dr. O. C. Bridgeman, they "gave the little lady a big hand." She began by saying that the gum in gasoline is not the Wrigley kind, but expressed no opinion, official or personal, as to which is the worse kind.

Gum may accumulate from the vaporization of fine liquid particles or of a deposited film; it would help to know just how as a basis for testing the true gum-content as it affects the engine. Variation in the amount of residue with the time of evaporation and the temperature introduces difficulties. Steam-bath evaporation gives results that are not proportionate for different amounts of gasoline evaporated. The problem is not yet solved, but the reported indications are that the true gum-content would be found by evaporating an infinitely small volume of an infinitely diluted solution in gum-free gasoline, which apparently would give a value about one-third that obtained by evap-

orating 100 cc. of the sample in air at 100 deg. cent.

In discussing this paper, Dr. A. E. Becker, of the Standard Oil Development Co., said that we must first decide upon some gum-measuring method that is reproducible and then correlate this to the effects in the engine, after which the question of stability can be attacked. Dr. Bridgeman replied that reproducibility is useless unless the test is significant.

Fuel-Line Temperatures Too High

Dr. Bridgeman then presented in abbreviated form the paper which he and H. S. White had prepared on Fuel-Line Temperatures in 1931 Cars. An equation and a chart were given for predicting the vapor-locking temperature for any gasoline from its Reid vapor-pressure, allowance for altitude being made in the chart. A refiner can control the gas pressure as necessary if he knows the temperatures to be encountered. As only ten 1931 cars have been tested for fuel-line temperatures, the results reported last year were the main basis of the paper. The average of 1931 cars tested was poorer than of the older models, one car suffering from a hot crankcase that made the fuel at the pump outlet 100 deg. fahr. hotter than the atmosphere.

Reiterating his observation of the benefit derived from moving the fuel line outside the chassis frame, Dr. Bridgeman said that manufacturers of the cars having high fuel temperatures can bring them to the level of the best with little expense and trouble. He believes that this should be done, to make possible the use of gasoline with better starting characteristics.

CLARENCE M. YOUNG, ASSISTANT SECRETARY OF COMMERCE FOR AERONAUTICS, AND VINCENT BENDIX, PRESIDENT OF THE SOCIETY

Discussion found a phalanx of oil men, including the Chairman, Dr. Becker; A. L. Clayden; G. G. Oberfell, of the Natural Gasoline Association; J. Bennett Hill, of the Atlantic Refining Co.; D. P. Barnard, 4th, of the Standard Oil Co. (Indiana); and J. M. Evans, of the Associated Oil Co., backing the plea for lower fuel-line temperatures, saying that more butane could then be used in the fuel. This would contribute to ease of starting and reduction of knocking, besides being a matter of economy.

Thus put on the defensive, W. S. James, of the Studebaker Corp., took up the cudgels and was seconded by E. S. Marks, of the Franklin Mfg. Co., and B. B. Bachman, of the Autocar Co. "It was only yesterday," they said, "when we were asked to give the gasoline more heat. We wish our product were all disposed of, like yours, in 30 days after it was made. It takes time to make changes in a car; and, if we change new cars tomorrow, you will still have to supply gasoline for present cars for years."

F. C. Mock, of the Bendix Research Corp., said that this was the first time the carbureter had not been blamed for everything about gasoline. Dr. Dickinson gave the comforting assurance that very few present cars that are not fitted with fuel-pumps are giving vapor-lock trouble; and the oil men, at least, went happily on to witness the water carnival.

Safety and Economy at High Speed

Speakers Advocate Driver Preparation for Safety and Streamline Cars To Reduce Wind-Resistance

WALTER C. KEYS, Vice-Chairman of the Passenger-Car Activity Committee, was Chairman of the Tuesday evening session. He visualized for our descendents speeds of 500 to 1000 m.p.h., under controlled conditions, when he introduced James E. Hale, of Firestone, as the dean of tire engineers.

Some Questions about High-Speed Driving was the title chosen by Mr. Hale, since he raised more questions than he was prepared to answer. The mere ability to steer a car at speeds between 60 and 80 m.p.h. under ideal conditions, he said, does not by any means make a man competent to drive a modern car upon the highways at the maximum speed of which it is capable; numberless complications of weather and road conditions, traffic situations, car characteristics and driver reactions combine into hazards of varying degrees. So little is actually known about the correct moves to make in such emergencies that an owner driving at such speeds is taking unreasonable chances, because he has not a proper understanding of what to do to get out of a tight place.

Experience has shown Mr. Hale that instinct cannot be relied upon to lead a man through such situations, for which, in fact, no sufficient background of human experience exists. Thinking is necessary, and all the preparatory thinking that is possible should be done in advance. Car designers have a definite responsibility to try to find the answers to questions that will arise and to educate and train the owners. A list of 18 questions was given by Mr. Hale as indicative of those to which answers should be known to high-speed drivers, most of them having to do with the best use of the brakes and maintaining steering control under various conditions of road surface and car behavior.

Some roads are being built and surfaced with material such that the program requires placing of signs "Very Slippery When Wet." Mr. Hale cites this as a condition that must be corrected, and he raised the question whether cars are being made as safe as they can be under high-speed conditions.

High-Speed-Driving Experience

Discussers found Mr. Hale's subject provocative. Bert Lemon and Past-President Beecroft cited experiences which indicated that blowing a tire at high speed is not dangerous if the brakes are not applied, especially if it is a front tire. "Cannon Ball" Baker said much the same in a letter that was read and also that he generally was obliged to revamp the steering-gear and reline the brakes of a car for high-speed work. Occasional testing of brakes on the surface of unfamiliar roads was advised by Dr. Dickinson. Garnet C. Brown, of Bohn Aluminum, said that steering-gears are designed for parking and low speeds. W. S. James stated the need for steering geometry that will not interfere with wheel direction when springs are deflected, and Murray Fahnestock relieved the tension by suggesting two-speed steering-gears. Fred Duesenberg stressed freedom from side-sway as he reported "cruising" at 100 m.p.h.

After contributions on the subject of driving from several other members, Chairman Keys asked the assembly to

PASSENGER-CAR-SESSION CHAIRMAN AND SPEAKERS

Walter T. Fishleigh, of Detroit, Who Advocated the Tear-Drop Design; Walter C. Keys, of Detroit, Chairman; and J. E. Hale, of the Firestone Tire & Rubber Co., Whose Topic Was the Driving of High-Speed Cars

rise. He presented it to Walter T. Fishleigh, who was then on the platform, as "The 1931 S.A.E. Audience." The auditorium was well filled, containing many ladies as well as men. Other presentations were made at this time, as chronicled elsewhere in this issue. Mr. Fishleigh's paper was on the subject of The Tear-Drop Car.

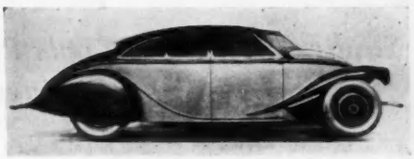
Body Design Too Long Static

Conventional enclosed cars have not advanced in aerodynamic design since 1913; in fact, according to Mr. Fishleigh, they are aerodynamically equivalent to the familiar milk-wagon. Since the lactic conveyance and the automobile represent extremes of speed, he suggested that something in the design of one of them must be wrong.

After presenting the history of motor-car development since 1803, with the aid of a large number of pictures and with special reference to body shapes, the speaker illustrated a large variety of streamline forms ranging from the blue whale and salmon grilse in the waters under the earth to the airplane and airship in the skies above it. He then presented a sketch representing the seats, floor, steering-wheel and roof of a five-passenger car and proceeded to throw around it a streamline form with the slightest possible breaks for a sloping wind-shield and a rear window.

Air-flow diagrams and curves from wind-tunnel tests were given to compare the disturbance of the air and the wind resistance caused by the tear-drop sedan thus produced with those caused by a conventional small sedan.

Mechanical details of one chassis suggested to conform to the streamline body were presented in a diagram. The engine is mounted directly above the rear axle on independent springs and connected to the transmission through transfer gears. The transmission contains the bevel-gear drive, and driving connection to the rear wheels is made through two universal-jointed shafts.



TEAR-DROP DESIGN DEVELOPED BY W. T. FISHLEIGH

Outstanding advantages claimed for the design are reduced fuel consumption, due to decreased wind resistance; clear vision, due to removal of the engine from the front end; increased riding comfort, because the seats are located between the axles; and beauty and grace, because of artistic streamlining.

Reduced Frontal Area Helps Trucks

Experience in freight transportation was cited by H. L. Horning as evidence of the advantage of reducing head resistance. At least six freight lines are being conducted in California to take advantage of the legal weight-limit of 68,000 lb. It has been found that adding weight affects the fuel consumption of these vehicles very little, so that weights of 34 tons are being transported on a gasoline mileage approximately the same as that of a 16-cylinder passenger-car. Frontal area seems to be the controlling factor. A close check on the gasoline consumption has been found to indicate the direction of the wind. Economy of 154 ton-miles per gallon is being reached in daily service. Directional stability he sees as one of the needs of a streamlined car.

Ventilation without excessive wind and a shower of honey-bees was mentioned by Roscoe C. Hoffman as something to be gained in a rear-engined car. Austin M. Wolf stated his belief that four-wheel driving is just as essential to driving safety as four-wheel brakes are to safety in stopping. Making the powerplant and driving unit in one unit is ideal for the production line, but it may entail a sacrifice in accessibility for maintenance. Four-wheel driving would retain the problem of transmitting the power from one end of the car to the other or else involve one powerplant at each end.

Passenger-Car Bodies Analyzed

Comfort, Interior Appointments, Chassis Features and Coordinating Instrumentation Presented

THE THREE PAPERS delivered at the Passenger-Car-Body Session on Tuesday morning, June 16, under the chairmanship of L. C. Hill, were entitled, Body Comfort and Interior Appointments, by H. A. Brunn; What the Body Engineer Wants in a Chassis, by R. F. Anderson; and Instrumentation as a Means for Coordinating Chassis and Body Design, by A. F. Denham.

Stylish Cars Can Be Comfortable

Mr. Brunn believes that the only method to secure both style and comfort is first to lay out the seating arrangement and then surround this with the body outline. Many stylish close-coupled cars are being sold, he said, but many of them are soon replaced by other cars that are more comfortable. After discoursing on fundamentals that govern the design of seat frames, springs, soft cushions and the like, he remarked that good style breaks down selling resistance, but comfort is the factor that keeps the car sold.

He advocated the revival of an application of the principles which governed coach building as an art in the olden days, and that body designers put more of their own personality into body designing.

During the general discussion, P. D. Paddock declared that seat design is extremely important. When a person sits incorrectly, his spine is in a position such that it can least effectively absorb jars and shocks. If tipped at the wrong angle, this shock-absorber cannot function. This results in undue

fatigue and unpleasant muscular and nervous excitement, which invites accidents when driving.

Adjustable seats should provide not only horizontal travel of the seat but a corresponding vertical rise, according to Herbert Chase. He believes that this provision should be made for the benefit of people of short stature.

What the Body Designer Wants

According to Roy F. Anderson, plans for 1933 cars should include the chassis-design factors most vital to the body designer, for each type of body model the line may include. Before proceeding with the scale and blackboard drawings, the body designer needs a preliminary chassis outline which shows all available tolerances for the wheelbase, the frame and cross-member heights, and the location of the dash, steering-wheel, radiator core and gasoline-tank filler. Cross-members should be located so as to avoid unnecessary obstructions for recessed floors.

Chassis-frame rigidity is essential for a quiet body and for the operation of the doors without strenuous effort. The body designer wants chassis-frame flexibility reduced to negligible fractions to avoid excessive body-weights, cost and service expense.

Comfort is affected by convenient access to the car's battery and to the tire-changing tools, and the body engineer wants more consideration given to this accessibility factor in the chassis design.

Following the paper, frame design was discussed by L. C. Hill. T. J. Litle, Jr., advocated weight saving by designing the frame and the body together, as already has been done abroad. W. S. James spoke on stiffness of frames, frames plus engine, and frames plus engine plus body, on four different cars. Maurice Olley stated the advantages of rating chassis stiffness in pound-feet per degree, as it has been proved that a limit exists beyond which it is not safe to proceed in stiffening a chassis frame torsionally.

Coordinating Instrumentation

Mr. Denham said in part that analysis and evaluation of experimental data are likely to make it possible, by rational design, to develop chassis and body combinations that will be satisfactory. For the time being, however, the problem resolves itself into cut-and-try procedures, at least until a definite system of instrumentation has been developed which will enable engineers to obtain the needed fundamental information. Instrumentation in this field should do one or both of two things: analyze a design for possible troubles or improvements needed, and indicate a means for correcting the design or achieving the improvement. Mr. Denham did not present a complete method and a definite type or types of instrument with which the true relationship of any body to any chassis can definitely be determined. Each individual car is a problem in itself, he said.

Recent studies on instrumentation made by his company were outlined by E. S. Marks in the general discussion of the foregoing paper. Among the other discussers were C. H. Colvin, of the Pioneer Instrument Co., and L. C. Hill. Mr. Colvin suggested the possibility that his company's recently developed vibration-recording instrument for measuring the vibration amplitudes and frequencies of airplane instrument-boards might be applicable to automobile-vibration study, and Mr. Hill outlined the instrumentation for the body-vibration studies that the Dietrich company has made.

Looking into the Future

Studies in Synthetic Oils Presented and Rear Mounting of Engines Advocated

FUTURE DEVELOPMENTS was the designation of the Wednesday morning session in the Assembly Hall, presided over by George L. McCain, Chrysler research engineer. The first paper presented was on the subject of synthetic lubricating oils, written by F. W. Sullivan, Jr., Vanderveer Voorhees, P. T. Oak and D. P. Barnard, 4th, who are research chemists and engineers of the Standard Oil Co. of Indiana. The paper was presented by Dan Barnard, who said that a synthetic oil probably has some advantages over any oil that is generally available; but the makers do not yet know how it will be utilized, and the paper was offered primarily to present a new idea of the characteristics of lubricating oil with respect to viscosity, temperature and behavior.

One method followed by the laboratory with which the authors are connected in their study of the composition of lubricating oils has involved their synthesis from a variety of olefins of differing structure. It has been found that lubricants of an extremely wide variety of viscosity characteristics can be prepared by polymerizing different olefins with a condensing agent such as aluminum chloride. Tables and charts were presented to indicate the variety of products obtained by this process, depending upon the basic material.

Uniform Viscosity Aids Shock-Absorbers

Synthesized oils have been made to the extent of many thousands of gallons during the last few years from olefins produced by cracking paraffin waxes. These oils have more nearly

PARTICIPANTS IN THE PASSENGER-CAR BODY SESSION

(1) H. A. Brunn, of Brunn & Co., Who Spoke on Comfort and Interior Appointments; (2) L. C. Hill, of Dietrich, Inc., Chairman; (3) A. F. Denham, of *Automotive Industries*, Who Described Instrumentation as a Means for Coordinating Chassis and Body Design; and (4) R. F. Anderson, of the Murray Corp. of America, Who Told What the Body Engineer Wants in a Chassis

constant viscosity with changes in temperature and have lower pour-tests than have natural oils of similar viscosities.

In practical tests, synthetic oils have shown superior qualities, particularly as regards cranking engines in cold weather and uniformity of action in shock-absorbers regardless of temperature. Mr. Barnard said that their principal advantages lie in the greater freedom which they allow the designer of mechanisms in regard to manufacturing tolerances, but that these oils are still in the development stage.

In reply to a question in the discussion, the speaker said that he can see no hope of such oils becoming as generally available as is the conventional type of motor oil. Paraffin wax, which is the starting point, is made in very small quantities, compared with the total amount of lubricating oils, and the amount of work required in making it means that, unless the oils are worth two or three times as much as conventional types of motor oil, they will be little used. The shock-absorber was mentioned by Mr. Barnard and by some of the discussers as apparently typical of the synthesized oil's best field.

Dr. Becker said that conditions would be ideal if the temperature of mechanism were uniform, or if an oil could be used of which the viscosity remains constant with change in temperature. He congratulated the authors on their approach to the latter ideal. The paper was also complimented by Neil MacCoull, of the Texas Co.; A. L. Beall, of the Vacuum Oil Co., who expressed interest because of the common difficulty in starting aeronautic engines; D. B. Morley, of the Mellon Institute; J. P. Stewart, of the Vacuum Oil Co.; W. G. Wall; T. C. Smith, of A. T. & T.; and A. L. Clayden, who compared the present state of lubricating oils with the steels of 25 years ago, when most of the American steel makers were unwilling to bother with a small market for a product like high-tensile steel which was very difficult to make.

Placing Engine at the Rear

Rear-Engine Mounting, the subject of the second paper, by Herbert Chase, was somewhat related to Mr. Fishleigh's paper on the Tear-Drop Car. Placing the steering-wheel in the center of an automobile and devoting most of the front half to powerplant seems

MORE FIELD-DAY EVENTS THAT CAUSED MEMBERS TO FORGET THEIR TECHNICAL PROBLEMS

(Upper Left) Make-Up Contest. (Upper Right) Balloon Race. (Center) Whoops My Dear. (Lower Left) All-Up Race. (Lower Right) Crab Race

absurd to Mr. Chase. Even a fairly long engine can be placed transversely at the rear of the chassis, and various cylinder arrangements are available that are not feasible for use under a normal hood in front, making the proportional length of chassis occupied by the engine much smaller than in conventional designs.

Grouping all the mechanism at the rear gives the body designer a free hand; a streamline form becomes possible for the complete vehicle, parts such as lamps and spare tires being enclosed. Larger seating space, a better position for the driver, improved riding-qualities and a saving in weight are held out as objects to be gained by moving the engine from the front to the rear. Scale models have demonstrated the seating space of a Lincoln on the wheelbase of a Ford.

Various available forms and arrangements of the mechanical units were enumerated, most of them calling for the engine, transmission and differential in a single, compact unit that is readily accessible and easily adapted for quick removal. Engine cooling and the control connections present two of the more difficult problems. Combining the controls in something approximating a common junction-block was suggested. Mr. Chase believes that the problem of arrangement can be solved in a way that will effect a mechanical improvement over conventional arrangements.

Discussers Both Write and Wire

Following the reading of the paper, Mr. Chase presented slides showing the construction of a considerable number of modern cars, both actual and projected, having rear-mounted engines. Written contributions were read from a number of discussers both present and absent, including H. B. Chalmers, president of the Jaray Streamline Corp. of America, and D. H. Montgomery, designs by both of whom were represented in the pictures shown by Mr. Chase. Thomas S. Kemble, chief engineer of the Pennington Engineering Co.; F. H. Dutcher, of Columbia University; and Lowell H. Brown, of New York, also submitted written discussions, and J. A. Anglada offered for the records one of a recent series of articles on the subject of rear-mounted engines by P. M. Heldt in *Automotive Industries*. Roscoe C. Hoffman, of Detroit, presented observations from experimental studies.

Cutting the powerplant in two and placing the passengers in the middle seems to Mr. Clayden to be ideal for riding comfort; placing the engine at either end seems to involve difficulty with weight distribution. R. F. Anderson, of the Murray Corp., said that placing the rear seat far enough ahead of the rear axle to allow for deep seat-springs is ideal. Efforts at streamlining are being made by body designers; and the problem is difficult, especially considering the looks of the car from various angles. A. M. Wolf, D. P. Barnard, 4th, and Past-Presidents Little and Wall also made contributions to the discussion.

Transportation Committee Reports Progress and Hears Meeting Plans

VARIOUS progress reports were made and plans for the National Transportation Meeting next autumn and for the Transportation and Motorcoach and Motor-Truck Sessions at the Annual Meeting next January were discussed at the meeting of the Transportation and Maintenance Activity Committee on Monday afternoon, June 15. The meeting was attended by 18 members of the Committee, and Chairman F. K. Glynn presided.

Chairman J. M. Orr, of the Committee on Equipment and Operation of Fleet Repair-Shops versus Manufacturers' and Commercial Repair-Shops, reported that members of his Committee have made contact with large fleet owners in various localities and questionnaires are nearly ready for distribution to them.

Chairman T. L. Preble, of the Committee on Problems Confronting the Transportation Engineer, reported that much valuable information is being received.

Nearly all of the papers and authors for the Transportation Meeting, to be held in the City of Washington next autumn and visits and inspection trips in connection with the meeting were reported to be definitely arranged for. To avoid conflict with the dates for the annual meeting of the American Petroleum Institute, the dates for the Transportation Meeting were changed to Oct. 27 to 29.

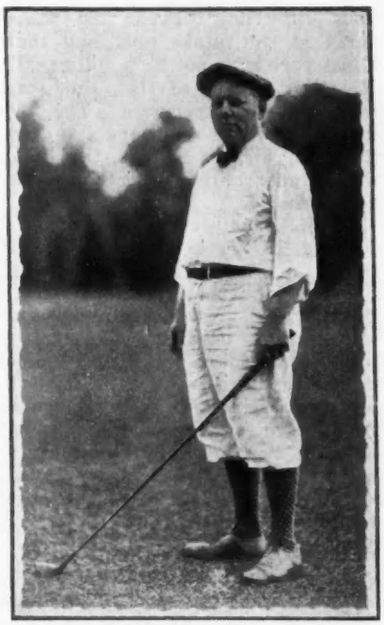
Following a joint discussion with the Motorcoach and Motor-Truck Activity Committee, agreement was reached to request the National Meetings Committee to schedule the Transportation and Maintenance and the Motorcoach

THOSE WHO TOOK LEADING PARTS IN THE FUTURE-DEVELOPMENTS SESSION

(1) George L. McCain, of the Chrysler Corp., Chairman; (2) Herbert Chase, of New York City, Who Presented Arguments for Placing the Engine in the Rear of the Car; (3) V. Voorhees, (4) D. P. Barnard, 4th, and (5) F. W. Sullivan, Jr., of the Standard Oil Co. (Indiana), Co-Authors with P. T. Oak of a Paper on Synthetic Lubricating Oils

and Motor-Truck sessions for the forenoon and afternoon of Wednesday at the Annual Meeting next January.

Progress on plans for securing new members was reported by Chairman H. V. Middleworth, of the Membership Committee.



NOMINEE FOR S.A.E. PRESIDENCY
Arthur J. Scaife, of the White Motor Co., Equipped as a Field Engineer

Following a report by Chairman J. F. Winchester, of the Committee on Chassis Record Forms, the meeting decided that these forms should be referred to the Motorcoach and Motor-Truck Division of the Standards Committee for submission at the Annual Meeting for adoption as S.A.E. Recommended Practice.

A progress report was submitted for E. S. Pardoe, Chairman of the Motorcoach Code Committee, which is cooperating with a similar committee of the Motorcoach and Motor-Truck Activity Committee.

Two reports were submitted for adoption by the Society as S.A.E. Recommended Practice. One was on Uniform Motor-Vehicle Operating-Cost Classification and the other on Standardization of Motor-Truck Chassis Lengths and Frame Widths.

Scaife Nominated for President at Business Meeting

PRESIDENT VINCENT BENDIX welcomed the guests at the opening of the business session Wednesday evening. The first item of business was action upon the reports of the various divisions of the Standards Committee, presented by its Chairman, A. Boor. These reports had been acted upon and modified, as reported elsewhere, at the meeting of the Standards Committee on Wednesday morning, and had been approved by the Council during the afternoon. They were adopted without further change by vote of the Society at this time.

President Bendix then called upon David Beecroft, Chairman of the Nominating Committee of the Society, who presented the names of the nominees selected by this Committee for submission to the membership by letter ballot. The names of these nominees will be found elsewhere in this Summer Meeting report. The various nominees were asked to stand as their names were read, each of those present being applauded. Arthur J. Scaife, nominee for President, was the last one named. He was escorted to the platform, at the call of the President, where he thanked the Committee in a few words for the honor done him and said that the thing uppermost in his mind was the wish to be worthy of the selection.

Standards Reports Adopted

Divisions Present Them at Standards Committee Meeting and They Are Adopted for Issuance

THE REGULAR mid-year meeting of the Standards Committee convened at the Greenbrier Hotel, White Sulphur Springs, W. Va., on Wednesday morning, June 17, with Chairman A. Boor presiding. The 25 reports prepared by 7 Divisions of the Standards Committee comprised original reports, a number of revisions of existing standards, and the cancellation of one aeronautic Recommended Practice that has become obsolete. All of the reports submitted to the Standards Committee were published in Section 2 of the June, 1931, S.A.E. JOURNAL.

The number of more or less minor modifications in some of the dimensions of a number of the reports were made because of further checks made on them, or because of additional information received since the reports were printed, all of these modifications being approved when the reports were presented.

The reports, as approved by the Standards Committee, were reviewed by the Council at its meeting on Wednesday afternoon, June 17, and approved for submission to the Business Session of the Society held that evening. Chairman Boor reviewed the action taken on the reports by the Standards Committee and the Council, and submitted them at the General Business Session for approval and adoption by the Society and publication in the July, 1931, supplement to the S.A.E. HANDBOOK. These reports, as published in the supplement, except as they may be acted upon by the Society at the Annual Meeting next January, will be incorporated in the S.A.E. HANDBOOK that probably will be issued early in March, 1932.

Attendance at the Standards Committee meeting, although relatively small, was representative of the various interests in the automotive industry to which the Standards and Recommended Practices submitted related. The members of the Standards Committee present were:

A. Boor, Standards Committee Chairman
R. S. Burnett, Standards Manager

C. E. Bonnett	W. H. Oldacre
R. J. Broege	Orrel A. Parker
J. R. Cautley	Harry N. Parsons
M. C. Horine	K. D. Smith
H. W. Graham	A. J. Scaife
W. C. Keys	R. R. Teetor
B. J. Lemon	Stanley Whitworth
E. F. Lowe	Thomas H. Wickenden
Arthur Nutt	

The members of the Society present who are non-members of the Standards Committee were A. E. Bronson, H. L. Horning and Edward P. Warner.

ARTHUR BOOR
Chairman of the Standards Committee

Truck Standards Report Amended

WITH an attendance of 22 members and guests of the Motorcoach and Motor-Truck Activity Committee of the Society, Vice-President L. R. Buckendale opened the doors of the Summer meeting on Sunday morning. Reports of progress were presented by

Chairman Scaife, of the Motorcoach Code Committee; Chairman Magoffin, of the Membership Committee; and Chairman Peirce, of the Truck Standardization Committee.

The report by Mr. Peirce was of most immediate importance, as it affected the report of the Motorcoach and Motor-Truck Division of the Standards Committee on motor-truck chassis dimensions, p. 26, Section 2, of the June S.A.E. JOURNAL. This was amended to include a tolerance of minus 0, plus 1 in. on the proposed distances from the extreme rear of motor-truck cabs to the center of the rear axles with the chassis unloaded. The designation of these dimensions was also changed from *BA* (back of cab) to *CA* (cab to axle) as being more nearly descriptive. The recommendation for the width of frame remained as published in THE JOURNAL. The subject of frame dimensions relating to the *CA* dimensions for six-wheel trucks was scheduled for study by the Motorcoach and Motor-Truck Division.

After reviewing and approving the program for the Motorcoach and Motor-Truck Session at the National Transportation Meeting of the Society in the City of Washington next Fall, the Committee voted unanimously to request the National Meetings Committee to designate Wednesday morning and afternoon of the Annual Meeting next January for one session each of the Motorcoach and Motor-Truck Activity and the Transportation and Maintenance Activity, which will cooperate in the selection of subjects to be presented at the respective sessions.

Aircraft-Engine-Session Analyses

Design Factors for Air-Cooled Cylinder-Heads and Present Status of Valves Stated

TWO SUBJECTS were presented at the Aircraft-Engine Session held Thursday morning, June 18, under the chairmanship of Arthur Nutt: Air-Cooled Cylinder-Head Design, by Roland Chilton, and Recent Valve Developments, by A. T. Colwell.

Mr. Chilton said in part that the two major requirements for good cooling are (*a*) adequate conductivity from the zones of maximum heat-flow—that is, the spark-plug bosses, the exhaust-valve seats, elbows and guides—to a sufficient area of finning, and (*b*) maintenance of a high-velocity airflow over the entire length and depth of all fins. He remarked that the latter problem depends on many items in the installation aside from the cylinder-head. The limit to possible power-output is set by detonation which, with a given fuel, depends upon the cylinder-head temperatures. These are the basic indices of operating conditions in air-cooled engines, and a cylinder-head thermocouple instrument should be standard equipment on each airplane, in Mr. Chilton's opinion. Pilots should be trained to respect cylinder-head temperatures as much as they now respect oil pressure and temperatures, he remarked. Much higher rating and cruising speeds could then be used with assurance under all normal conditions, because the cylinder-head-temperature indication will give warning before harmful conditions are reached.

Chairman Nutt remarked in the discussion the likelihood that the reason for better cooling is due to the impact of the air on the fins. During the development of the British Schneider Cup Races, he said, investigations were made of the cooling power of radiators installed on the wings. It was found that, around the leading edge of the wing, the cooling effect was seven times greater than it was on the top and bottom surfaces of the wing, which is clearly due to the impact of the air on the front surface. Therefore, by tipping the cylinder slightly and getting the impact on the side of the fins, it probably cools better for the same reason. He also discussed the effect of streamlining engines. In reply to Harold Nutt's question as to the most suitable location for installing a thermocouple, Mr. Chilton answered that thermocouples are installed on the first engine of a given type. It is then determined which cylinder in that particular installation tends to run the hottest; thereafter, on succeeding engines, a thermocouple is installed on that one.

G. C. Brown said that the tremendous difference between the temperatures at the intake port and the exhaust port have not been fully realized. Mr. Chilton replied that this was in line with his experience. The widening of the valve seats and the division for good airflow around the back of the cylinder reduces the temperatures, he continued.

H. M. Bramberry remarked on the sticking of piston-rings, saying that the piston temperatures have, no doubt, a great influence on this. With the short types of piston used and the number of rings used, he said, it is impossible to reduce the piston temperature without increasing the heat flow across the rings to the cylinder-wall. Mr. Chilton replied that the most hopeful cure lies in the high-compression engine. If the fuels get better, more of the heat will then go into useful work and less of it will flow to the cylinder-walls.

Poppet-Valve Developments

Increased speed, mean effective pressure and piston displacement of engines have made both aircraft and automobile-engine exhaust-valves subject to far more severe conditions than formerly, according to A. T. Colwell. Power increase in aircraft engines has increased valve-operating severity; on automobiles, engine speed has increased approximately 21 per cent, brake mean effective pressure 19 per cent, and piston displacement 8 per cent in the last few years.

Higher compression alone is favorable to valve temperature, Mr. Colwell continued, but when this is coupled with higher speeds and improved volu-

PARTICIPANTS IN THE AIRCRAFT-ENGINE SESSION

A. T. Colwell, of Thompson Products, Inc., Author of a Paper on Recent Valve Developments; Arthur Nutt, of the Wright Aeronautical Corp., Chairman; and Roland Chilton, of the Wright Aeronautical Corp., Whose Subject Was Air-Cooled Cylinder-Head Design

metric efficiency, more heat passes the exhaust valve in a given time. The hottest part of an exhaust valve is the radius portion under the head. A shield for this part was illustrated and described as well as a shroud to protect the end of the valve-stem guide. Cooling the valve increases its life. Salt and sodium cooling were compared and methods of sealing the coolant in place were described. The construction and behavior of copper-cooled valves were discussed, as was also a one-piece hollow-head valve. Reasons for using valve-seat inserts were given.

Robert Jardine said in part, in the discussion, that the use of a valve material having substantially the same coefficient of expansion as that of cast iron helps more than anything else. Most of the good heat-resisting materials have too great a coefficient of expansion, he continued. When they get hot—which they do because they are poor heat-conductors, just as in the case of the valve itself—they are forced inwardly and squeezed inwardly so that, when they cool, they loosen rather than remain tight.

In conclusion, Mr. Chilton testified that almost all of the discussion at this session illustrated a point he has always tried to emphasize. It is that when a designer has trouble, his thought is that if the material manufacturer only would provide a much stronger material, this would suffice. But usually, he said, a change in the basic design eliminates the cause of the trouble.

Sounds of Revelry by Night

LAUDATORY comments upon the Grand Ball were numerous, the only adverse criticism being expressed by one young lady who declared that it was not half long enough. On Thursday evening at 10:30 o'clock, technical men who have achieved reputations as experts in various fields turned their attention to just one line of endeavor and exerted themselves to prove their expertness in the theory and practice of dancing. In this attempt they were so enthusiastically aided and abetted by their wives and other ladies that the judges, consisting of non-participants on the side lines, considered the evidence and, without leaving their reviewing stand, rendered a favorable verdict.

The major activity of the evening was interrupted, briefly but enjoyably, by a buffet supper served at midnight. Afterward the dancing was resumed and continued until, at 1:30, the strains of Good-bye, Girls, I'm Through foretold the end of a most pleasurable evening, giving way very soon to the more sentimental and chivalrous but equally inexorable melody, Good-night, Ladies, which brought to a close the chief social event of the Summer Meeting.

CHAIRMAN AND SPEAKER AT THE AIRCRAFT SESSION

The Hon. David S. Ingalls, Assistant Secretary of the Navy for Aeronautics, Who Spoke on Aviation in the Navy, and Dr. George W. Lewis, of the National Advisory Committee for Aeronautics, Who Presided

Ingalls Brings Navy to Mountains

Secretary Gives Address Illustrated with Motion Pictures of Panama Canal Maneuvers

FOLLOWING the business session on Wednesday evening came the Aircraft Session, for which President Bendix turned over the gavel to Dr. G. W. Lewis, of the National Advisory Committee for Aeronautics, who is Vice-President representing aircraft. He in turn introduced the Hon. David S. Ingalls, Assistant Secretary of the Navy for the Air, presenting at the same time a brief outline of the history of the Navy in the air.

Secretary Ingalls began his talk with an expression of the respect felt by laymen, especially those who have some connection with engineering activities, for the S.A.E. The airplane carriers, which take a complement of about 80 airplanes each over the water at approximately 40 m.p.h., he considers the greatest weapon of offense and defense that man has ever devised.

War Maneuvers Shown on Screen

Most of the motion pictures presented were taken during the war maneuvers at the Panama Canal last winter. They showed the carriers going through the canal and its locks, airplanes of various types landing and taking off from the decks of the carriers and flying in formation, the arrangement of planes huddled on the deck, and views of the elevators and other details of the carriers. One of the newest types of plane that was shown was the Curtiss Hell-Diver two-seated fighter.

Secretary Ingalls explained the pictures as they were shown, so that the whole was a very interesting illustrated address rather than a motion picture. The working out of the war problem was followed by showing the officers and radio operators at their tasks, the dropping of depth charges and the launching of torpedos. Dive bombing was seen from the viewpoints of both a spectator and the bomber, and some of the precautions to protect the men in case of forced landings were depicted. The Secretary called attention to the fact that one of the fliers got lost, and his plane was supported in the water for 24 hr. by air bags in the wings. Then the officer floated around for five days in a rubber boat, inflated from a bottle of compressed air, before he was rescued. He said that his chief worry was because of the sharks which were all around him.

Sections Constitution Revised

FOR SOME TIME there has been a demand from our Sections for a revision of the Sections Constitution, By-Laws and Rules to bring these regulations more closely into line with the reorganized arrangement of the parent Society, particularly as regards the officers and Activities. The revised form, which had previously been sent to all Sections for criticism, was submitted to the Sections Committee at

its meeting at White Sulphur Springs, and the Committee unanimously recommended to the Council that the revisions be accepted as written.

This recommendation was unanimously approved by the Council.

The revised Sections Constitution and By-Laws has already been approved by the Detroit Section and its 1931-1932 organization is in accord with the new provisions governing Section officers.

Student Plans Suggested

The Sections Committee also recommended to the Council that no further attempts be made to inaugurate Student Branches in the technical colleges, for the present at least; as an alternative plan, it was suggested that the various Sections should include in their activities a meeting or meetings or inspection trips of special interest to students, the extent of this work to be determined after the completion of a survey of the technical schools and colleges in their territory. It was understood that the five Student Branches of the Society as already established should have the Society's fullest cooperation and assistance. Action on this matter was deferred by the Council.

Studies of Riding Comfort

Wabblemeter and Other Instruments Count and Measure Accelerations and Fatigue Effect

RIDING COMFORT is ranked near the top of the list in the characteristics in the design of any new car by Vice-President E. S. Marks, chief engineer of the H. H. Franklin Mfg. Co., who acted as Chairman of the Chassis Session held in the Ballroom Thursday morning. Papers on riding comfort are scheduled for each Annual and Semi-Annual meeting, he said, and the Research Committee of the Society has been delving actively into the definition and measurement of riding comfort. The subject is related to all the major elements of the car.

The Tire Factor in Automobile Riding-Quality was the subject of the first paper, given by R. W. Brown, who is in charge of the engineering laboratories of the Firestone Tire & Rubber Co. Desire for higher speed, he said, has stimulated the development of tires, as well as other elements of car design, and instruments have been developed to measure the performance. Determination of body and axle frequency makes it possible to prevent synchronism between them. Body frequency is little affected by the tire, so a size can be selected that will prevent synchronism.

The solenoid accelerometer, which was described in the S.A.E. JOURNAL for May, provides means for counting and measuring vertical accelerations. Differences as small as 5 lb. per sq. in. of inflation pressure can be detected consistently, and the guesswork of riding-comfort observers can be eliminated, said Mr. Brown, who recommended interpretation by plotting the number of accelerations per mile against accelerations in feet per second per second.

Mr. Brown showed on the screen a hydraulic compression machine and a typical load-deflection curve plotted from tests made on it. The curvature of such a graph varies with changes in details such as shape and thickness of tread, cord angle and number of plies. He also presented a composite chart showing various characteristics for a range of tire sizes. Traction is one factor in tire performance that he regards as being still in the research class.

Discussion of this paper had to do largely with questions of rim diameter and width, raised by Maurice Olley, of Cadillac, and K. D. Smith, of Goodrich. Rim diameter was said to influence tire life, and wide rims were said to improve riding-qualities and stability.

Records from Latest Wabblemeter

Two papers on riding comfort followed. Dr. F. A. Moss, of George Washington University, presented further results of tests with the latest type of wabblemeter, made since the tests reported in the S.A.E. JOURNAL for May. The possibility that fatigue observed during a day's ride might be normal, even if the subject were inactive, suggested tests on several subjects who remained inactive during the day. These showed that their steadiness improved considerably during the forenoon and until 2 p. m. and decreased again only slightly up to 6 p. m. Corrections to make comparisons with normal for various times of day

CHASSIS-SESSION CHAIRMAN AND SPEAKERS

(1) R. W. Brown, of the Firestone Tire & Rubber Co., Who Discussed the Tire Factor in Riding Comfort; (2) Dr. F. A. Moss, of George Washington University, Who Made a Report on Road Tests with the New Wabblemeter; (3) E. S. Marks, of the H. H. Franklin Mfg. Co., Chairman of the Session; (4) Dr. Ammon Swope and (5) Prof. H. M. Jacklin, of Purdue University, Who Reported Some Observations on Riding-Qualities

would therefore increase the indicated effect of fatigue from riding.

Riding-tests shown indicate almost complete recovery of steadiness after a long rest in the middle of the day and rapid increase in fatigue in driving over a poor and muddy road in the rain, partly after dark. General observations were to the effect that unsteadiness increases more rapidly in the driver than in the passengers and slightly more in a front-seat passenger than in one in the rear seat. At the conclusion, the wabblemeter was demonstrated on a subject.

Purdue Tests Reported

The final paper, Observations on Riding-Qualities, presented by Prof. H. M. Jacklin, was written jointly by him and Dr. Ammon Swope, both of Purdue University. This paper reports study of psychological effects on the driver, the forces and their frequency at various points in vehicles on the road, and the effects of vertical harmonic vibrations on individuals.

The psychological effects were observed during an extensive lubricating-oil test on the Indianapolis Speedway, in which 13 representative stock cars were driven at various speeds for a total distance approximating 100,000 miles. The steadiness meter described in the S.A.E. JOURNAL for May was used to measure the nervous reaction of the drivers. Most of the records from 30 drivers indicated a slight gain in steadiness after driving thus without traffic complications. The contrast from previous study suggested that much of the apparent fatigue arises from mental attitudes created because of road situations.

Forces acting in vehicles were studied by the aid of an accelerometer having one weight arranged to vibrate vertically and another horizontally. It can be mounted on the floor of a car or in a dummy "passenger" placed on one of the seats. Tests were made on seven cars operating on the Speedway and highways at different speeds. Records of fore-and-aft vibrations vary with the number of cylinders in the engine, and vertical accelerations depend in character and frequencies upon the springing of the car.

For studying the effect of harmonic vibrations, a "shake table" was constructed that could be subjected to vertical vibrations of widely varying frequencies and amplitude. "Passengers" sit on two wooden-seat chairs. Tests were made on a number of subjects to determine the types of vibration that were perceptible, pleasing, bearable, uncomfortable, disagreeable and unbearable. The greatest tolerance to vertical vibration is found at frequencies of 2 to 3 per sec., approximating the tempo of walking. These tests seem to indicate that acceleration is not the controlling factor in riding-qualities.

Turnover in Technical Men

Horning Analyses Discontent and Mixes Eulogy with Suggestions for Improvement

E. K. WENNERLUND, director of the production engineers of the General Motors Corp., was Chairman of the Production Session of the Meeting, Thursday evening. The speaker was Past-President Harry L. Horning, president and general manager of the Waukesha Motor Co., and his subject was Why Technical Men Leave Home.

The anguish caused by the necessity of reducing working hours or turning old and trusted employes out into a world that does not need them was referred to feelingly by the speaker.

Industry is more or less helpless in times like these unless it has built up huge resources of cash and has not over-capitalized the earning power of its better years. From extensive observation it appears that leaders of industry are willing to make almost any sacrifice before resorting to reductions in remuneration or organization.

Turning to the question of what a technical man can do to assure his own employment during such periods, Mr. Horning said that nothing can take the place of the value of his services to an organization. When the dire necessity of figures drives companies to clean house in order to survive, length and regularity of service come next to excellence as determining factors.

Live Fish Swim Upstream

When a man comes to a stall in keeping up with the business, it is a tragedy. Few men make great effort for advancement. Perhaps unconsciously they seem to try only to hold their jobs. The speaker suspects a layer of subconscious discouragement to be insidiously corroding in most men's hearts, and this sometimes causes a man to voluntarily try to change his position. The major cause of turnover lies in imperfect choice of men and in failure of the management to surround the men with conditions which permit them to do their best work. The cost of turnover among technical men is insignificant compared with the possibilities that lie dormant in most of them.

Management receives its greatest encouragement and a man his best chances of achievement when he is willing to give his untiring effort to perfecting himself. Such efforts always produce results if they are well and persistently directed. The most discouraging thing to a management is to feel that a man is trying to live beyond his position.

Field Observations Require Analysis

Technical men should be creative; sometimes they are brought down to the level of clerks by routine work and the domination of standards and rules. They have a most difficult task in visualizing what the public wants and they are frequently criticized for honest work which is predicated on false information. This results in dissatisfaction and a change in position or a loss of caste.

Some turnover Mr. Horning considers to be necessary. Usually the first thing that is necessary to save a falling company is to put into effect a much delayed turnover and weed

GENERAL-PRODUCTION SESSION CHAIRMAN AND SPEAKER

E. K. Wennerlund, of the General Motors Corp., Chairman; and H. L. Horning, of the Waukesha Motor Co., Who Discussed Technical Labor Turnover in Industry and Its Cost

out men who have been allowed to deteriorate. A technical man improperly placed can lose more for his company than all the other employes together. It is often a benefit for both the man and the company for such a man to leave; it may help the man to find his correct place in the world.

Greater attention to the study of human nature in education would make technical men more valuable in their work. Some of them appear to be thinking entirely in a world detached from men. The tendency toward individualism keeps some technical men from a better understanding of their associates and the world at large and interferes with their cooperation and coordination.

Representing one of the best types of men that our civilization has created, management has its greatest opportunity in making conditions such that dormant possibilities can be developed and the greatest returns be realized from the investment in these men.

Engine-Development Phases

Automotive Fans, Oil Consumption, and Starting from Cold Featured at Concluding Session

THREE PAPERS were presented at the concluding session held Friday morning, June 19. G. C. Brown was chairman. A. D. Gardner presented the paper on Reducing Horsepower and Noise of Automotive Cooling Fans, H. C. Mougey dealt with Oil Consumption as Affected by Engine Characteristics, and P. J. Kent analyzed Automobile - Engine Low - Temperature-Starting Development.

Reducing Fan Horsepower and Noise

Stating the automotive cooling-fan problem as being constituted of the delivery of more air, decrease of fan horsepower, reduction of fan noise so that it is comparable with or less than other powerplant noises, and the installation of the fan in a restricted space, Mr. Gardner described the testing apparatus and methods used in analyzing the subject. Fan speeds and the most effective number of blades were then considered, followed by analyses of fan diameter, pitch, and blade curvature. The manner in which air is discharged from the fan, and the adaptation of a cooling fan to an automobile were also described.

N. S. Diamant stated in the discussion that further work is necessary to determine more definitely the values of the exponents used and the extent to which they are influenced by such factors as the number of blades and the like. Further investigations are necessary to determine the effect of the many variables. The fifteen items given in the summary, he concluded, are borne out by general experience and should prove very valuable for reference purposes. L. P. Saunders remarked that it is impossible to draw any conclusions concerning the fan efficiencies, due to entire lack of static-pressure figures. Voluminous written discussion was also presented by Louis Schwitzer, of the Schwitzer-Cummins Co.

Engine-Characteristics' Effects

According to Mr. Mougey the problem of oil consumption must be solved before the problems of winter starting and winter lubrication can be solved, since these require light oils which give poor results in regard to oil consumption at present. In order of their importance the factors affecting oil consumption are: Engine speed, oil leaks, design of the lubricating system and changes due to wear, oil viscosity, oil volatility, pour test, possibility of effects from carbonization of the oil-control rings, and length of time between oil changes. Some of the reasons why these factors affect oil consumption and suggestions as to various methods of overcoming these difficulties were given.

In the discussion, Alex Taub discoursed on engine speed and oil leaks.

R. E. Wilkin presented data on a series of tests of 13 makes of 1931-model passenger-cars made on the Indianapolis Speedway with regard to oil consumption. R. N. Janeway discussed the subject of engine-bearing life. W. E. Lee amplified some of Mr. Mougey's conclusions. Sydney Bevin remarked regarding the amount of lubricating oil lost because of blow-by past the pistons that sweeps the atomized oil out of the crankcase through breathers, fillers or vents. C. M. Larson presented voluminous prepared discussion, illustrated with lantern slides.

Low-Temperature-Starting Tests

P. J. Kent's paper dealt with the testing and design of equipment which is of vital importance to assure successful low-temperature starting of automobile engines. This depends upon positive supply of fuel to the carbureter, means for cranking the engine over a reasonable period of time and at a reasonable speed, mixing the fuel and air in correct proportions for firing, delivering this mixture to the cylinder, and igniting the mixture. "Starting should be foolproof," Mr. Kent remarked.

Many Interested in Autogiro

MEMBERS interested in the Autogiro had a unique opportunity of hearing a simple description of this machine and seeing it in operation on Thursday afternoon. A two-reel sound motion picture illustrating the behavior of the craft both on the ground and in the air and reviewing the presentation by President Hoover of the Collier Trophy to Harold F. Pitcairn on the occasion of the Autogiro's flight to the White House grounds in Washington, was shown in the Greenbrier auditorium. Edward P. Warner was in the chair and after a brief talk on the possibilities of the "windmill," invited all the members to proceed to the Greenbrier airport one mile from the hotel.

AUTHORS OF PAPERS PRESENTED AT THE ENGINE SESSION

A. D. Gardner, of the Automobile Fan & Bearing Co., Who Described Tests for the Reduction of Fan Noise and Power Consumption; P. J. Kent, of the Chrysler Corp., Who Described Methods of Developing the Low-Temperature Starting of Engines; and H. C. Mougey, of the General Motors Corp., Who Told of the Effect of Engine Characteristics on Oil Consumption

Here were assembled the Lockheed airplane which Joe McDuffee, of the Prest-O-Lite Co., had flown to the meeting, several Travel Airs, a trimotored Ford that brought Clarence M. Young to the meeting, a Bellanca, and the Autogiro. The Hon. David Ingalls had left earlier in the day in his Hell-Diver.

A. E. Larson, chief engineer of the Autogiro Co. of America, made a special trip to be present and preface the entertaining and instructive motion-picture feature with an elementary explanation of the basic principles of autogiration. Lieut. J. T. Jeters, U. S. N., who, by the courtesy of the Navy Department, Bureau of Aeronautics, had been detailed to fly the Autogiro to the airport and authorized to demonstrate it, was in the auditorium and was introduced by the chairman.

The Society, at the suggestion of Loren R. Johnston, managing director of the Greenbrier Hotel, extended a general invitation to the people of the countryside, who turned out in great numbers, many coming down from the mountains with their whole families and making a day of it. One old man nearly ninety years of age, hearing of the expected arrival of McDuffee in his plane, had brought his 10-year-old grandson to see the ship.

Scenically, the Greenbrier airport is one of the most beautiful in the Country and one of the few in this mountainous locality.

Research Committee Very Active

Cooperative Diesel-Fuel Committee Formed—Gasoline Study Endorsed—Subcommittee Projects

THE MEETINGS at White Sulphur Springs gave no evidence of a depression in the field of research. Not content with a full schedule of meetings of the Research Committee and its Subcommittees, the fuels and lubricants groups reconvened for second sessions, and it became the order of the week to expand the meetings into an adjoining parlor to accommodate interested visitors.

The Fuels Subcommittee met on Sunday to organize a joint committee of the S.A.E. group and the A.S.M.E. Special Research Committee on Diesel-Fuel Specifications to carry out a program of Diesel-fuel research on a cooperative plan. O. D. Treiber was named chairman and Wiley H. Butler, secretary. The direction of the work was placed under the guidance of an executive committee, with Dr. H. C. Dickinson as research supervisor, and a ways and means committee headed by M. J. Reed.

Gum and Sulphur Programs Endorsed

The gasoline group of the Fuels Subcommittee held a separate meeting and endorsed both the program of research on permissible gum content, approved in principle by the Cooperative Fuel-Research Steering Committee at its last meeting, and a proposed program on sulphur limits. The Steering Committee, at a special informal meeting on Monday, heard the report of Dr. G. W. Gray's special subcommittee on sulphur research and approved the proposed program.

The Detonation Subcommittee spent half a day in lively discussion over the final details connected with the specially designed carbureter and in arranging for a series of cooperative tests to make possible the approval of the test engine and its equipment by Sept. 14.

Members of the Front-Wheel-Alignment Subcommittee came into agreement on the conclusions to be drawn from the survey conducted at the General Motors Proving Ground under the direction of this group and voted to request that the Passenger-Car Activity provide a session at the next Annual Meeting for consideration of the problem of wheel alignment from its various angles.

The Highways Subcommittee held a short session to consider items connected with the cooperative tests on motor-truck and motorcoach impact that are being conducted by the Bureau of Public Roads, and agreed upon certain suggestions to be made to the Cooperative Motor-Truck Impact-Test Committee at its next meeting.

A report by Dr. F. A. Moss and a joint paper by Dr. Ammon Swope and Prof. H. M. Jacklin presented at the Chassis Session constituted progress reports on the riding-comfort project. Dr. Moss's plans for future work were approved by the Committee. Plans for financing the work were discussed and to this end a definite recommendation was made for consideration by the Society's Council.

On a recommendation of the Shock-Absorber Subcommittee, the Research Committee approved the work accomplished by that group since its formation in January and voted to turn over the project to the Standards Committee.

To Correlate Lubricants Tests

The Lubricants Research Subcommittee, authorized by the Research Committee last January, met to prepare its report, which states the purpose of this undertaking to be the development of tests to evaluate the properties of extreme-pressure lubricants and determine the lubrication requirements of gears and bearings, with the idea of correlating the tests on the oils with the requirements of the gears and bearings. The report proposed that the directing committee be composed of axle, truck, automobile, bearings and oil producers and motor-vehicle operators, and included suggestions for personnel which were approved by the Research Committee.

Council Discusses Wabblemeter

Decides Not To Indulge in Patent Business—Approves Resolution To Study Truck Rating

AFTER receiving a report and suggestions from the Riding-Comfort Subcommittee through its Chairman, R. W. Brown, with regard to the proposed patent of the wabblemeter, invented by Dr. F. A. Moss, Dr. H. C. Dickinson and R. W. Brown, the Council, at its meetings on June 15 and 17, at White Sulphur Springs, adopted substantially the alternative recommendation submitted to it by the Riding-Comfort Subcommittee. The Council decided that the Society should not enter the patent business in any way that would involve the Society in the administering of patents and carrying on the various business transactions that would necessarily be related thereto. It was directed that the acquirement of the wabblemeter patent should be handled privately and not as an official operation of the Society. It was also felt that the manufacture and distribution of wabblemeters should be left to the discretion of the patentees.

In considering this matter, it was understood that private funds would be forthcoming and that expert talent would be placed at the disposal of the patentees. The Council gave evidence of its recognition and expressed commendation for the very excellent and practical piece of work that has been accomplished by Dr. Moss and his associates. Dr. Moss has shown a very rare combination of talents in the study of the riding-qualities problem and has, for the first time in history, accomplished a coordination between the physiological and psychological reactions of a passenger and instrumental methods for their determination.

To Study Truck and Bus Rating

By F. K. Glynn, Vice-President representing Transportation and Maintenance Engineering, a resolution, later approved by the Council, was submitted asking that permission be granted for the Transportation and Maintenance Activity and the Motorcoach and Motortruck Activity Committees to form a joint committee to make recommendations of a generally acceptable scheme for the rational rating of motor-trucks and motorcoaches. This resolution was inspired by a comprehensive discussion of the matter of rating that took place at the Sunday evening session on Motor-Trucks and Motorcoaches.

Technical Assistance to Regulatory Bodies

The Council recommended that an investigation be made of the possibilities for the Society to become more effective in a purely technical manner as a source of information and engineering guidance to Federal, State and municipal organizations in whose power rest the formulation and administration of laws and regulations touching upon the automotive industry which require the consideration of technical problems.

The Council directed that the staff be authorized to canvass the membership for the purpose of determining how many members are willing to subscribe for THE TRANSACTIONS at a price covering the cost of printing.

It was reported to the Council that the National Automobile Chamber of Commerce has granted its annual appropriation of $5,000 which, coupled with the appropriation of a similar amount by the American Petroleum Institute, will be used to finance further work of the Cooperative Fuel-Research Committee.

Jones Wins Golf Tournament

THE 1931 S.A.E. Golf Tournament on June 18 consisted of a 36-hole Medal Play Tournament of four flights. The Championship Flight was played on a gross basis and was won by R. F. Jones with a total score of 36 holes in 156. The Runner-Up was won by J. B. Shea with a score of 159. Mr. Jones is with the Russell Mfg. Co., of Middletown, Conn., and Mr. Shea is with the Cleveland office of the Firestone Tire & Rubber Co.

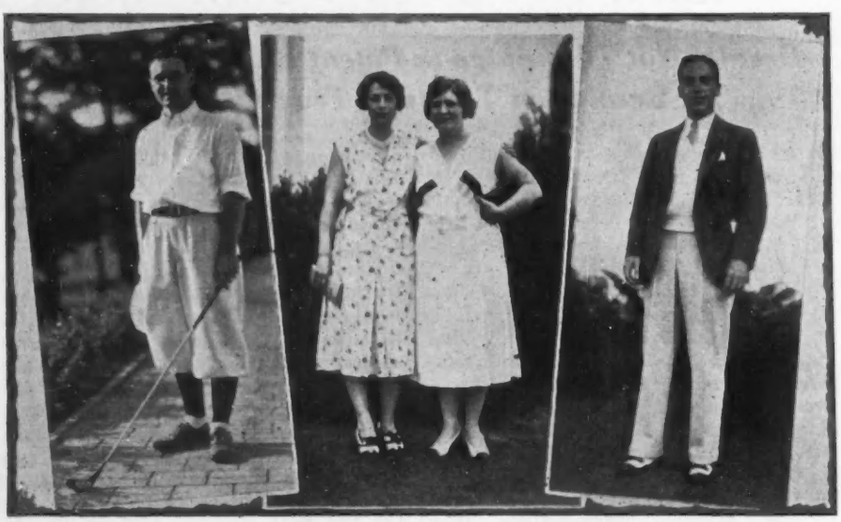
The A, B and C Flights of this tournament were played on the handicap basis. A flight for those whose handicaps were from 15 to 22 was won by Gordon Brown, of the Bakelite Corp., with a net score of 36 holes in 143. A. C. Chambers, the runner-up in this flight, scored 144.

The B Flight was played in a dead heat by R. F. Steeneck and H. A. Hansen. Their net total of 36 holes was 137. In a toss of the coin, Mr. Steeneck won and walked away with the first prize, leaving Mr. Hansen as runner-up in this flight.

In the C Flight H. C. Horner, of the General Motors Corp., was away out in front of the second-place man by 12 strokes, Mr. Horner scoring a net 133 and H. L. Ames, runner-up, a net 145.

The Championship Flight developed into a very strenuous contest, with Chairman Anderson, Sharpe, Burke and McDuffee in a close race at the end of the qualifying round. This round, along with the free-for-all swimming race that evening, seemed to tell on these men in their final rounds the next day, so much so that Joe McDuffee "shot a score of 200 for 15 hr. lying in bed." He is all right now!

The Sweepstakes Tournament, played on Sunday, developed into a very interesting event. Of the 300 or more golfers who checked in at Greenbrier on Sunday, 299 entered this blind-par two-ball sweepstakes. At the conclusion of the afternoon, of those who played the 17 holes in this tournament, the lucky number golfers to take the first prize were J. P. Stewart and Ray F. Townsend, their number being 78 net. Second prize was divided among S. H. Martin, Gordon Brown and Stanford Brown. Only two divided the third-place prizes—D. E. Gamble and Donald Alexandra—they having a 75 net. On the whole, this year's tournament proved very satisfactory, and the weather conditions were ideal.



WINNERS IN MEN'S AND WOMEN'S GOLF CHAMPIONSHIP FLIGHTS

R. F. Jones, Winner of Men's S.A.E. Golf Championship for 1931. Mrs. J. B. Funk, Winner, and Mrs. Stanley Whitworth, Runner-Up, in Ladies' Championship Flight. J. B. Shea, Runner-Up in Men's Championship Flight

Contract Supplants Auction

THE LADIES' bridge games, always an important feature of the Summer Meeting, proved to be of more than usual interest this year because of the added stimulation furnished by the change from auction to contract bridge. Moreover, the ladies who took part in the games were given an opportunity to increase their knowledge of the principles of contract bridge.

C. Paul Ray, Jr., of Bryn Mawr, Pa., an amateur of high standing and winner of the Metropolitan bridge tournament, was present throughout the week and generously contributed his time, energy and skill in conducting the games and giving to those who participated the benefit of his advice and instruction. At the conclusion of the playing each morning, Mr. Ray lectured informally on the subject that he is so admirably qualified to discuss, receiving the rapt attention not only of the ladies who had just finished playing but also of their husbands, who came, after the adjournment of the technical session, presumably to take their wives to luncheon but who were observed to linger in the doorway with every appearance of being eager to improve their bridge game by listening in on the same splendid instruction that their wives were enjoying. According to Mr. Ray, the scores indicated that the playing of the 60 ladies who participated in the bridge tournament improved more than 50 per cent during the week.

To Orrel A. Parker are due the thanks of all concerned with the success of the tournament, as it was through his interest and courtesy that the invaluable services of Mr. Ray were obtained.

The winners were as follows: Monday, Mrs. C. O. Skinner, first, and Mrs. J. T. Kennedy, second; Tuesday, Mrs. Alex Taub, first, and Mrs. Jack Gray, second; Wednesday, Mrs. O. A. Parker, first, and Mrs. A. E. Becker, second; Thursday, Mrs. L. F. Poock, first, and Mrs. T. H. Wickenden, second. The highest score for the week was recorded for Mrs. A. E. Becker, and the next to the highest by Mrs. Harry E. Figgie.

Field-Day Events Stir Risibilities

Fifteen Novel Contests Call for Dexterity and Celerity and Prove Hilariously Ludicrous

IMMACULATE weather and a big crowd, with S. S. Dickey in fine form as Director, made the S.A.E. Field Day a roaring success. As usual, most of the events were sprung as surprises, and every one of the 15 Dickey-doings was provocative of mirth and plenty of exercise.

The circus started with a Crab Race, in which men raced on all fours with paper bags over their heads so that they could not see. The results were very comical, as none of the contestants knew when the race was over and so kept on going erratically until stopped. The winner was E. C. Rodgers, with C. S. Bruce second.

Then came the Block Race. Each man was given a 12 x 3-in. block, one for each foot. At the start, all stood on their blocks; at the whistle they lifted each block alternately, by hand, put it ahead and stepped forward on the blocks as rapidly as they could. Any contestant stepping on the ground was disqualified. A strong back and lots of patience won the prize, W. E. England being first and C. S. Bruce second.

The Match-Box Passing contest, with three men and three women on a team, was provocative of much laughter. Firsts: C. S. Bruce, Mrs. Bruce, R. S. Drummond, Miss Alice Brown, D. P. Barnard and Mrs. Barnard; seconds, A. G. Haskell, Mrs. Haskell, Mrs. D. M. Borden, C. B. Bishop, Murray Fahnestock and Mrs. Fahnestock.

Teams Go Through Hoops

Three men and three women made up a team for Whoops My Dear, and each team was given a hoop. The first man in each line stood in the hoop and at a signal pulled it up over his head and passed it to the lady behind him, who in turn pulled the hoop down over her head to her feet. When the last lady in the line got the hoop, she ran to the head of the line around the judge, passing the hoop back in the same way. Winning team: A. G. Haskell, Mrs. Haskell, Mrs. D. M. Borden, C. B. Bishop, Murray Fahnestock and Mrs. Fahnestock; second team, W. E. England, Mrs. C. S. Salzman, Mrs. H. V. Middleworth, J. T. Greenlee, Mrs. A. L. Beall and Donald Brooks.

The All-Up Race was the fifth event, only men taking part. Two blocks are used; one flat on the ground, the other placed vertically on it; the object being for each man in turn to run to his block and, with one hand, change the positions of both blocks. He then touched the next man in line, who did the same thing. Firsts: H. E. Figgie, A. J. Poole, D. B. Grassett, F. K. Glynn, C. F. Oestermeyer and M. J. Brennan; seconds, D. P. Barnard, J. T. Greenlee, Edward P. Warner, A. C. Nuth, J. M. Evans and H. N. Parsons.

In the Sack Relay six men on a team were given a burlap bag. At the whistle the first man in each line put both legs in the bag and jumped to a point 25 yd. away, returned, got out of the bag and gave it to the next in line. The same teams won first and second prizes in this race as in the All-Up Race.

Women Find Clothespin Race Hard

In the Clothespin Race, exclusively for women, each woman was given five clothespins; at a signal all raced to a clothesline and placed the five pins one at a time on the line with their teeth. Hands were not permitted to be used except to place the pins in their mouths. As may be imagined, the contestants found it very difficult to hit the line,

MR. AND MRS. MURRAY FAHNESTOCK
Winners of the Make-Up Contest in the Field-Day Events

which was in constant violent motion. The event was won by Mrs. D. M. Borden; with Miss Alice Brown second.

The eighth event, Balloon Blowing, evoked more than the usual amount of hilarity. Each woman was given a tough rubber balloon to inflate and at a signal blew and blew until the balloon burst. The expressions on the contestants' faces were those of surprised agony and great relief. First, Miss Alice Brown; second, Mrs. G. T. Greenlee.

No battle royal ever furnished more action than the Chef Boxing, which followed. Each man was given a paper bag of 12-lb. size and a newspaper. Putting the bag on his head and one hand behind him, he tried to knock his opponent's paper hat off with the rolled newspaper. Losing his hat put the contestant out. A Stribling-Schmeling fight would be tame in comparison. First, C. B. Bishop; second, E. C. Rodgers.

When Men Picked Light-Weights

"Oh! you are too heavy, get us a lighter one" was the cry on all sides when the Sedan Relay Race was announced. Six women and two men made up a team; the women lined up and the two men made a sedan seat with their clasped hands. At a signal they carried one woman at a time to the finish line. The winning team included C. S. Bruce, Mrs. Bruce, Miss Alice Brown, D. P. Barnard, Mrs. D. M. Borden, Mrs. Murray Fahnestock, Miss Helen Schatz and Mrs. Grace Janeway; second team: Mrs. A. G. Haskell, H. E. Figgie, Mrs. E. P. Warner, Mrs. Sarah Glynn, Mrs. J. H. Smith, Miss Charlotte Anglada, Mrs. C. R. Maxon and P. P. Pierce.

In the Kid-Boots Derby 24 women were seated in chairs in a line and each woman was given four 14-lb. paper bags. In two of the bags she placed her right and left shoes, then the bags were placed in a pile about 25 yd. away. Using the other two sacks as boots on their feet, the women at a signal were required to run the 25 yd., find their own shoes, put them on and race back. The winner was Mrs. A. G. Haskell, with Miss Helen Schatz second.

For the Ten Trips event three women made up a team and stood in line about 10 ft. apart. At the whistle the first woman threw a bean-bag to the second, who in turn threw it to the third and she back to the first. This was one "trip." When ten had been made, the judge, a man, standing behind No. 1, grasped her around the waist and raised her up, announcing completion of the task. Firsts: Mrs. C. S. Bruce, Miss Alice Brown and Mrs. D. M. Borden; seconds, Miss Helen Schatz, Mrs. Sarah Glynn and Miss Charlotte Anglada.

The Roly-Poly was much advertised as "easy and requiring no running," but proved to be quite a stunt. Each contestant was given a roll of tissue paper. At the starting signal all got down on their knees and, with their noses, began to unroll the paper. The first man to unroll his roll won the prize. Luckily there was no wind. First: C. B. Bishop; second, D. P. Barnard.

Girls Know Their Cosmetics

Twelve couples entered the Make-Up Contest, each woman being given a lipstick, an eye-brow pencil, a box of rouge, a box of powder and a powder puff. Five minutes was allowed for them to do as much damage as they could to the physiognomy of their chosen males. The winners were Murray Fahnestock and Mrs. Fahnestock, with F. K. Glynn and Miss Charlotte Anglada second.

The Egg-Throwing Contest was better than last year and the boys who won this contest certainly knew their eggs. Some of the spectators were unkind enough to say they thought theirs were boiled or made of china. J. T.

Greenlee and A. C. Nuth were the winners, and D. B. Grassett and J. M. Evans took second prize.

Gordon Brown Wins the Water Carnival

DESPITE lateness of the hour, several hundred members and their wives gathered at the side of the Greenbrier Pool at 10:30 on Monday night for the Water Carnival. C. N. (Bunny) Dawe, with S. S. Dickey acting as scorer, put on a great aquatic show of 12 events, with more than two dozen contestants, 12 of whom made points. As usual, the Brown Brothers, buoyant and breathing hard, kept the pool in constant agitation.

Mrs. Hergenroether and Mrs. Fahnestock, the only women in the contest, tied for first place, with scores of 32 points each.

In the men's division, Gordon Brown ran up a score of 26 points, winning first prize, while C. S. Bruce, in second place, trailed him with 17.

Following free-style races for men and women, there was a Candle Race during which lighted candles were held in the mouths of the swimmers. This and the Nightshirt Race, the Ball and Spoon, the Dice Race, the Lucky Number, and the Pan-on-the-Head furnished plenty of amusement for the spectators. The Glove Race and Blindfold Race, which concluded the evening, kept the crowd in a hilarious mood.

Mrs. Whitworth Wins Ladies' Golf Tournament

MRS. WHITWORTH, the wife of Stanley Whitworth, vice-president of the Bendix Aviation Corp., won the Championship Flight in the Ladies' Golf Tournament with a low gross of 155 for 36 holes. She did this by shooting 79 in the first round and 76 in the final. Mrs. J. B. Funk was runner-up with 160—76 in the first 18 and 84 in the second 18 holes.

In the Ladies' Handicap Tournament, Mrs. B. W. Knight won with a net score of 134 for 36 holes, the runner-up being Mrs. J. G. Monjar, who had a net 136.

The Ladies' Tournament was played on No. 2 Course at Greenbrier, which is especially built for ladies and consists of nine beautiful holes, well trapped, with plenty of water, lots of rough and tall trees, and is regarded as one of the sportiest nine-hole courses in the eastern part of the Country.

DETONATION SUBCOMMITTEE OF THE COOPERATIVE FUEL-RESEARCH STEERING COMMITTEE

Meetings Committee Lays Plans

A DINNER-MEETING of the National Meetings Committee was held on Monday, June 15, the second day of the Summer Meeting. After a few brief remarks regarding the National meetings scheduled for the remainder of the current administrative year, the site of the 1932 Summer Meeting was discussed. The Committee requested the Society staff to submit the qualifications of several suitable places from which the Meetings Committee could choose two or three to be submitted to a vote of the membership for final decision.

A brief report was made on the Production Meeting held in Milwaukee in May, which was sponsored by the Society's Production Activity and held with the cooperation of the Milwaukee Section. The Meetings Committee went on record as favoring the holding of meetings in close cooperation with local Sections whenever and wherever the success of the meeting, together with an increase of prestige to the Section and a saving of money, would seem to be assured by such procedure.

Summary of Organized Sports

Golf Tournament

Ladies

Championship—First, pewter tea set, Mrs. S. W. Whitworth; second, sterling compote, Mrs. J. B. Funk.

Handicap Flight—First, Telechrone clock, Mrs. D. W. Knight; second, pewter bowl, Mrs. J. G. Monjar.

Golf Tournament

Men

Championship—First, Telechrone clock, R. F. Jones; second, pewter mixer, Joe Shea.

Flight A—First, Telechrone clock, Gordon Brown; second, cigarette box, A. L. Chambers.

Flight B—First, Telechrone clock, R. F. Steeneck; second, cigarette box, H. A. Hansen.

Flight C—First, Telechrone clock, F. C. Horner; second, cigarette box, H. L. Ames.

Driving Contest—First, golf bag, Gordon Brown.

Bridge Tournament

Ladies

Monday—First, overnight bag, Mrs. C. O. Skinner; second, perfume bottles, Mrs. J. T. Kennedy.

Tuesday—First, sterling sugar and cream, Mrs. Alex Taub; second, ash tray, Mrs. Jack Gray.

Wednesday—First, lamp, Mrs. O. A. Parker; second, sandwich dish, Mrs. A. E. Becker.

Thursday—First, Telechrone clock, Mrs. L. F. Pooch; second, sterling salt and peppers, Mrs. T. H. Wickenden.

High Score Points

Field-Day Sports

Ladies—First, lady's overnight bag, Mrs. D. M. Borden (tied for first, no second); lady's overnight bag, Miss Alice Brown.

Men—First, man's kit bag, D. P. Barnard; second, cigarette box, C. B. Bishop.

High Score Points

Water Carnival

Ladies—First, lady's overnight bag, Mrs. M. Fahnestock (tied for first, no second); lady's overnight bag, Mrs. E. J. Hergenroether.

Men—First, Telechrone clock, Gordon Brown; second, cigarette box, C. S. Bruce.

Metropolitan Section Visits Fort Hancock

COL. J. C. JOHNSON and Capt. W. C. Thee were hosts to Metropolitan Section on Saturday afternoon, June 6, when more than 200 members and guests visited Fort Hancock, Sandy Hook, N. J. The voyage there was made by fast boat through New York Harbor, and the return by special train directly from headquarters at the fort.

The First Motor Repair Section's full complement of tactical equipment was drawn up for review by the arriving party, which was accorded full military honors to the tune of Hail, Hail, the Gang's All Here, by the 52nd Coast Artillery Band. The address of welcome, made by Colonel Johnson, was a brief but interesting review of the history of Fort Hancock.

Following the greeting, groups were formed to visit the points of interest. At the motor repair shops it was explained that the Army system of maintenance consists of five echelons: (*a*) the vehicle operator's maintenance, (*b*) the fleet operator's maintenance or inspection, (*c*) the major repairs by unit replacement, (*d*) repair of unserviceable units, and (*e*) reconstruction of units and sub-assemblies. The shops at Fort Hancock do fourth-echelon work for the Second Corps area on Army vehicles operated in New York, New Jersey and Delaware.

Atmospheric corrosion tests being made by the American Society for Testing Materials were viewed with interest. Iron and steel articles of various shapes having protective coatings, such as zinc, cadmium, lead, aluminum, electroplated cadmium, and sherardized articles, are exposed to the Sandy Hook weather, which is typical of seacoast conditions in the temperate climate. It was obvious that a hot-dipped zinc finish was proving highly satisfactory so far.

Heavy Artillery and Historic Sights

The 12-in. guns at Batteries Kingman and Mills were explained in some detail by Colonel Johnson, who made them do all their tricks except actually fire. These guns have a range of 30,000 yd., throwing a projectile weighing 975 or 1070 lb., with a powder charge of 270 lb.

At the Railway Artillery Park were 8-in. rifles mounted on railroad carriages and having a range of 22,000 yd., together with 12-in. railroad mortar batteries having a range of 16,000 yd. The railroad equipment includes ammunition, kitchen and mess cars.

Other points of interest visited by means of Mack, White and other buses furnished to Colonel Johnson, were the Sandy Hook lighthouse, oldest in the United States, built in 1764; the oldest United States life-saving station, built 1848; the landing place of Hendrik Hudson in Horseshoe Cove; the remains of a Civil War fort built in 1857; and the location of Capt. Kidd's tree, killed by gold-diggers of the Victorian era.

After the sightseeing, swimming and fishing had been concluded for the day,

TYPICAL SCENES ON THE METROPOLITAN SECTION BOAT TRIP TO AND INSPECTION AT FORT HANCOCK, SANDY HOOK

a hearty, old-fashioned shore dinner was served from Army field-kitchens, with plenty of chowder, hand-dipped clams, red lobsters and trimmings for everyone. Then came dancing, followed by good-byes, the train and New York.

A trip through the Empire State Building is still on Metropolitan Section's schedule for shortly after the Summer Meeting of the Society.

Indiana Pre-Race Meeting

Annual Section Event Draws Record Crowd—Builders and Drivers Discuss Car Features

THE ANNUAL racing-car and driver meeting of the Indiana Section, held on May 21 in Indianapolis, drew a record crowd of 250 engineers, racing men and local automobile men to a round-table discussion started with reminiscences by Chairman Louis Schwitzer, who gave some of the early history made on the Indianapolis Speedway.

Lee Oldfield then covered the pertinent and radical features of the new race cars. He opened the way for discussion by showing a decrease in front-wheel-drive cars, with no new entries of this type, the increasing importance of the near-stock contenders, telling of Snowberger increasing the speed of his $1,600 car by 10 m.p.h. since the 1930 race, and by giving high praise to Leon Duray for bringing the first two-stroke-cycle engine of its type to the track. Mr. Oldfield expressed his belief that there should be more two-stroke engines, considering how greatly the 500-mile-race rules favor this type whereas it is penalized in other lands.

In the discussion, Leon Duray led the field as brilliantly as he did in the time trials some years ago when he set the record of 124 m.p.h. for one lap, which still stands, as well as his qualifying record of the year at 122 m.p.h. He said that one reason why he did not build a front-drive car this year was that he had only about $20,000, "and front-wheelers do cost a lot," adding that if he had built a 16-cylinder four-cycle car and did anything with it, he would be accused of copying either Harry Miller or Fred Duesenberg. His first idea was a four-stroke-engine car. Then he experimented with a small two-stroke engine and found that, for power, efficiency and everything but fuel conservation, it seems laps ahead of other types. He was not at all concerned about fuel saving for his purposes and was more than satisfied to take his chances with the new problems he has encountered along with the seemingly improved qualities that he has found in power, efficiency and speed.

In his picturesque and breezy manner Duray kept the crowd in gales of laughter as he shot fast ones over that seemed as snappy as the multiple exhaust of his two-stroke sixteens. His was the best driver speech ever heard in Indianapolis, and nailed several engineers to the mast when he put his heavy foot down on irony, deft sarcasm and wit that always got a laugh even from those hardest hit. His discussion was as complete and satisfying as his new cars, which all the analytical dopesters agreed are, with the Cummins Diesel, the most interesting of the really new things introduced this season.

Snowberger Explains Faster Stock Car

Ralph Snowberger told how he bought for $1,600 a stock car that had raced 40,000 miles and then been driven 30,000 additional miles over the road, and took fourth place in the National championship last year, and to which he has now added 10 m.p.h. by a few cheap gadgets and a new body. It was admitted that he had added about 30 per cent to the output of the engine at the speed at which the car runs. He also spoke in favor of rules requiring less weight per horsepower.

L. L. Corum also spoke and Waldo Stein, the tire wizard, told briefly of the tire problem and predicted that more drivers this year would go through the race without a tire stop if weather conditions were near to those of last year.

Fred Duesenberg added a few brief and witty yarns of the old-timers' days, and Bert Dingley said that he believed that, when racing men take near-stock cars and increase their power output as Snowberger and others had done, it is increasingly important to factories to keep their eyes on races and learn from them.

New Officers Elected

The announcement of the mail-ballot vote for next year's officers showed votes from more Section members than had ever voted in Indiana, with practically unanimous choice of the officers set up by the Nominating Committee two months previously. The new officers are: Chairman, H. M. Jacklin, associate professor of mechanical engineering, Purdue University, West Lafayette; Vice-Chairman, Louis Schwitzer; Treasurer, Charles A. Trask; and Secretary, Harlow Hyde.

The 500-mile race, run on May 30, subsequent to the Section meeting, was a disappointment from the technical standpoint in that the faster cars were wrecked largely because of oil on the track. One fast near-stock car that was in second place went through the wall. The race resulted as usual, with Miller and Duesenberg cars taking the first five places, Snowberger's near-stock Duesenberg being fifth. Duray had heating trouble, the water-cooling system of his car being inadequate. As predicted by Waldo Stein, the tires proved remarkable and no wreck was caused by a blowout. Harry Hartz protested the award of first place to Schneider, claiming that during the rain that lasted for an hour, when the cars were slowed down and the drivers instructed to maintain their relative positions, Schneider crept up on the Hartz Duesenberg more than enough to make up the 44 sec. that separated the two cars at the finish. Louis Meyer also protected awarding of third place to Hepburn in the Miller Special, claiming that the Judson Special which he was driving at the end of the race, finished in third instead of fourth place.

Pittsburghers Make Merry

EIGHTY members of the Pittsburgh Section sat down to the annual Stag Dinner in the Cardinal Room of the William Penn Hotel the night of May 27, which had been postponed from the scheduled date of May 21. And nearly a score more dropped in later to enjoy the Frolic. Holding the belief that "variety is the spice of life," the officers feel that the members are entitled to "all fun" at the last meeting of the season. Consequently, there was the sound of revelry and hilarity before the night was over.

Following the dinner, John M. Orr, Chairman of the Section, called attention to the six meetings held during the past season as the best assurance that the Pittsburgh Section should be even better next season. He recalled briefly the enjoyment of the rapid-fire talk given by V. R. Jacobs, of the Goodyear-Zeppelin Corp., on Sept. 25, which aroused so much interest that a large group from the Section went to Akron, Ohio, to see for themselves the new Navy dirigible and its giant dock. On Oct. 23 the Section acted as host at the National Transportation Dinner of the Society, at which Frank R. Phillips, now president of the Philadelphia Co., was principal speaker. On Dec. 11 M. A. Eason, of the Leece-Neville Co., spoke on Voltage Control. On Jan. 15 the brake-symposium meeting was attended by 244 who were interested in the subject. On Feb. 26 A. E. Feragen spoke on Steering Alignments. In connection with the joint meetings of the Pittsburgh Section of the Society and the Automotive Coun-

cil of the Pittsburgh Chamber of Commerce on the subject, Pittsburgh's Place in the Automotive Industry, the first annual exhibit of made-in-Pittsburgh automotive products attracted much interest.

New Officers Elected

Election of the following officers of the Pittsburgh Section for the 1931-1932 season was announced: Chairman, B. H. Eaton, of the Bell Telephone Co.; Vice-Chairman, C. R. Noll, of the Gulf Refining Co.; Secretary, Clyde R. Mathis, of the White Co.; and Treasurer, Murray Fahnestock, of the *Ford Dealer & Service Field* magazine. A hearty vote of thanks was tendered to retiring Chairman Orr, of the Equitable Auto Co.

Then the program of fun began! It included Mary Ann and six personality girls, who gave mirth-provoking acrobatic and interpretive dancing. Following the blondes came the brunettes—six colored combatants, who staged a "battle royal" in which many a resounding whack was given and taken, while members of the Section acted as towel-wavers.

Even that was not all, for there was a show-after-the-show, which was subsequently called "the show of shows" by those who attended.

Autogiro Demonstration Staged

Alfaro Explains Principles with Model at Philadelphia Section Meeting

AT THEIR MAY 13 meeting, the Philadelphia Section members enjoyed an afternoon and evening with the Autogiro. The afternoon session was held at the Pitcairn Aviation Field, where several of this relatively new type of machine were put through their paces. A group of the members who were fortunate enough to draw lucky numbers were given demonstration flights in the ships. The evening session, preceded as usual by a dinner and entertainment, included a talk by Heraclio Alfaro and the showing of several reels of motion pictures of Autogiros in various maneuvers.

Probably the most interesting feature of the Autogiro is the nearly vertical descent possible. Of almost equal interest is its ability to travel at a rate not faster than that at which a man can run. This was demonstrated clearly in the motion pictures.

Lifting Power of Rotor Shown

Mr. Alfaro has been associated with the development of the Autogiro almost from its inception, having been an admirer and co-worker of Juan de la Cierva's for a number of years. His address was in a somewhat popular vein, describing the development of the Autogiro to its present state and predicting its future possibilities. During his talk he demonstrated, by means of a small table-model, the great lifting power provided by the relatively small area of the Autogiro's rotor blades. In lifting effect the blades are more than equivalent to a disc the size of the surface swept by the rotor.

According to Mr. Alfaro, the Autogiro provides three distinct advantages: (*a*) safety, since it eliminates the possibility of stall and tail spin and should provide a much safer machine for blind flying than the conventional airplane; (*b*) utility, since it can land in very restricted spaces and take off with runs decidedly shorter than the conventional airplane; and (*c*) comfort, since the flexible rotor provides a very noticeable cushioning effect in rough or bumpy air.

Mr. Alfaro was frank in stating that in some respects the Autogiro is inferior to the airplane, but he said that methods of improvement in these respects are known and the performance of the machine will be continually improved.

Questions Raised in Discussion

Some interesting discussion followed presentation of the paper, and the question arose as to the possible top speed of the Autogiro. Mr. Alfaro likened the Autogiro in this respect to the airplane, saying that it is a question of wing loading, or disc loading in the case of the former, a large rotor providing a slow, truly vertical descent resulting in a slower ship. If the rotor is made smaller, so that the loading is high, higher speeds can be obtained but at the sacrifice of a slow vertical descent. The factor of allowable descending velocity depends upon the ability of the undercarriage to absorb and withstand the shock of vertical landing, and, as the carriage or structure may be improved, the higher rates of vertical descent will be permissible. If the requirement of practically true vertical descent is eliminated, high speeds in the Autogiro are feasible with present types of construction, while still providing a landing speed much below that of an airplane having the same top air-speed.

As usual, there was considerable questioning as to the forces that maintain the rotor blades in motion, and Mr. Alfaro demonstrated very nicely, both on the blackboard and with the table model, that the rotation is caused by the motion of the blades through the air and does **not have any** relation to the slipstream of the propeller, nor, as some suppose, by a direct connection to the engine.

Oregon Section Meets in Vancouver

WITH 33 members and guests in attendance, the Oregon Section held the last meeting of the Section year at Vancouver, Wash. Those who arrived early in the afternoon enjoyed a game of golf at the Clarke County Country Club, and it is reported that some played to even scores standing since the meeting of last summer in Longview.

E. S. Lindly, Secretary of the Vancouver Chamber of Commerce, and H. L. Hirchler, Past-Chairman of the Northern California Section, were guests of honor at the banquet held in the Evergreen Hotel.

Speakers during the evening were Mr. Lindly, who welcomed the Section to Vancouver and expressed the hope that the good time enjoyed would lead to the selection of the city as a meeting place again; Mr. Hirchler, who spoke briefly on the connection between the engineering and research work done by the Society and the problems of the service man; and C. M. Cartwright, who gave a short history of the Bureau of Public Roads and the work done by the Washington State Highway Department.

Two reels of motion pictures were shown of Eddy Pullen driving a Ford car from Los Angeles to Phoenix, Ariz., and return in record time. The fact that the car did not have wings failed to hinder it from getting up in the air for long stretches at many places on the road.

The members present voted to change the meeting date of the Section for the coming year from the second to the first Friday of the month, as it was thought that better attendance would result and more time would be allowed to prepare reports of the meetings for publication in the S.A.E. JOURNAL.

Although the meeting adjourned early, most of those present remained until nearly midnight, enjoying a social get-together and renewing old and making new acquaintances.

Buffalo Aquatic Meeting

THE JUNE meeting of the Buffalo Section was held Saturday evening, June 6, at the Buffalo Launch Club, located at Grand Island, Buffalo.

Members of the Section had prepared a program of four afternoon races at the Club for outboard and runabout craft. Francis Brobeil, a sensational

(*Concluded on p.* 100)

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DR. JOSEPH S. AMES

Chairman of the National Advisory Committee for Aeronautics

Aircraft-Engineering Research Conference

Reports on Last Year's Work Presented and Full-Scale Wind-Tunnel and Seaplane-Float Towing Channel Dedicated at Sixth Annual N. A. C. A. Gathering

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ADMIRAL D. W. TAYLOR

Vice-Chairman of the National Advisory Committee for Aeronautics

THE National Advisory Committee for Aeronautics staged its Annual Aircraft Engineering Research Conference at the Langley Memorial Aeronautical Laboratory, Langley Field, Hampton, Va., on May 27. This conference, the sixth to be held, was a gathering of executives and aeronautic engineers of the aircraft industry and representatives of the Army, the Navy and the Department of Commerce, with members of the National Advisory Committee for Aeronautics and the technical staff of the Committee at Langley Field. Approximately 200 representatives of the industry gathered to take advantage of the presentation of the results of research work carried on by the Advisory Committee during the last year and the opportunity to suggest to the Committee plans as to the technical problems involved in improving the design and construction of aircraft and aircraft engines.

Reports Show Great Strides Made

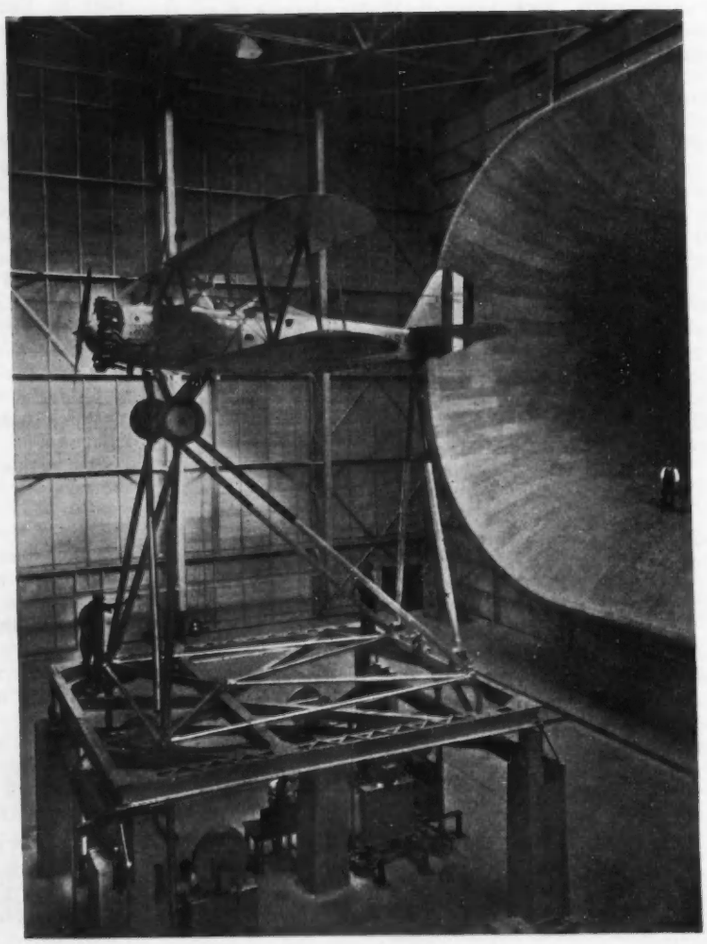
The tremendous strides made by the Committee in the last year, both in the development and the building of equipment and the work accomplished, were clearly demonstrated. Among the reports presented to the conference were:

Survey and report on location of engine nacelle on an airplane with reference to wing

Propeller efficiencies as affected by location of engine nacelle with reference to wing

Wing-tip loading, as a result of measurements in flight of the pressure distribution on a number of forms of wing tips

Leading-edge loading on wings of high-speed airplanes



FULL-SCALE WIND-TUNNEL DEDICATED AT LANGLEY FIELD

The Enormous Size of the Tunnel Is Shown by the Size of the Man Standing in the Opening of the Tunnel Section

Results of wind-tunnel tests and flight tests on a number of different types of airplane

Results of laboratory tests and demonstration flight-tests on a number of types of airplane

Results of extensive wind-tunnel investigation on the Handley Page slot, as to proper location. Demonstration of an airplane fitted with slots and flaps

Results of extensive investigation showing the effect of camber, thickness and position of maximum thickness

Comparison of different types of landing-gear as to shock-absorbing properties

New type of propeller-hub dynamometer

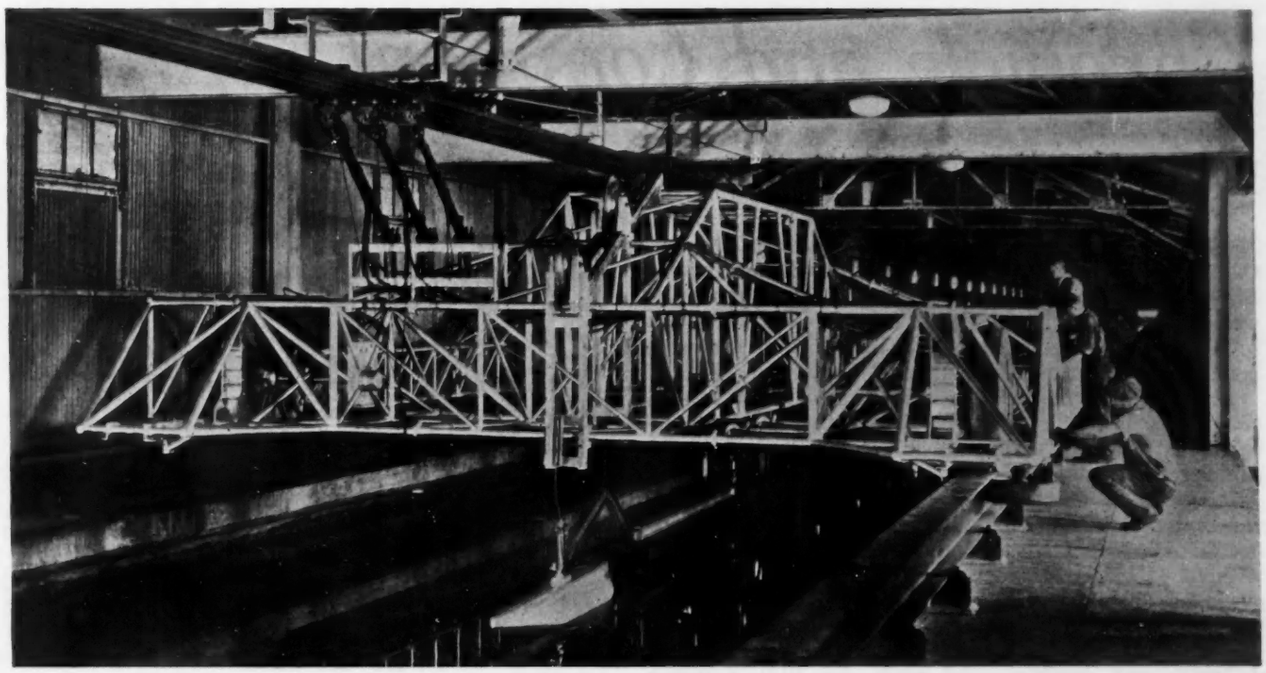
Demonstration of safety fuels with compression-ignition engine

Fire hazard in airplane crashes; cooling of exhaust manifold, with demonstration

Two-stroke-cycle air-cooled engine

Comparison of centrifugal, Roots and vane-type superchargers

Advance made in development of compression-ignition engine, and the spray combustion-chamber.



SEAPLANE-FLOAT-TOWING CHANNEL JUST PUT INTO OPERATION AT THE LABORATORIES OF THE NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

The Towing Carriage Is Supported on Large Pneumatic Tires and Operated by Electric Motors. It Runs on Steel Rails and Has a Maximum Speed of 60 M.P.H. The Channel Is Nearly ½ Mile in Length

Tunnel and Channel Dedicated

In addition, the dedication and demonstration of the only full-scale wind-tunnel in the world, which has recently been completed and in which was mounted a Vought Corsair for demonstration.

This equipment makes possible the testing of full-size airplanes at a speed of 115 m.p.h. in a jet of air 60 ft. wide by 30 ft. high. The dedicatory speech at the opening of this wind-tunnel was delivered by Dr. George S. Ames, chairman of the National Advisory Committee for Aeronautics.

Similarly, Admiral D. W. Taylor, vice-chairman of the National Advisory Committee for Aeronautics, dedicated the world's largest seaplane-float towing channel, which is nearly ½ mile in length, 24 ft. wide and 12 ft. deep and is provided with a towing carriage having a maximum speed of approximately 60 m.p.h.

To exaggerate the importance or the value of these annual conferences to the aeronautic industry is impossible, as was ably attested by the presence of the majority of well-known engineers and executives of the industry.

Report on Alloys-of-Iron Research

THE ALLOYS-OF-IRON RESEARCH was organized in 1929 by The Engineering Foundation with the assistance of an advisory committee appointed by the American Institute of Mining and Metallurgical Engineers. T. H. Wickenden, the Society's representative on the Committee under whose direction the work is being conducted, calls attention to the first progress report recently issued by that group.

This report states that the purpose of the Alloys-of-Iron Research is threefold:

(1) To review critically all research work on iron and its alloys, as reported in the technical literature of the world from 1890 to date, and to assemble the data thus collected in a form convenient for reference

(2) To publish information collected by this critical review in two kinds of books: (*a*) monographs, for the scientist and research worker; and (*b*) manuals, for the technician, the executive, and the engineer in the ferrous industries and related fields

(3) To call attention in these books to errors in existing data; to define clearly the gaps now present in our knowledge of the alloys of iron, both of pure alloys and of commercial irons and steels; and to encourage and promote research for basic facts to fill these gaps.

The editorial office of the Foundation has made a list of nearly 2000 publications in 10 languages which contain information on iron and its alloys. This list is virtually complete for all periodicals published in 25 countries since 1890. The more important of these publications have already been critically reviewed and each article abstracted in as much detail as its importance warranted.

Individual alloy systems have been assigned to cooperating groups. The literature pertaining to the particular system is being reviewed by that group to provide a nucleus for preparation of the monograph. Among these cooperating groups are the Battelle Memorial Institute, the Carnegie Institute of Technology, Lehigh University and the National Bureau of Standards. A bibliography of the iron-silicon alloys and silicon-alloy steels, prepared by the Lehigh University group, is reviewed in the Notes and Reviews section of this issue of the S.A.E. JOURNAL.

Chronicle and Comment

Fourteen Hundred and Fifty Technically Exposed As a measure of the engineering interest that was shown at the Summer Meeting, there is considerable significance in the fact that the attendance at technical sessions aggregated 1450. Committee meetings this year were unusually well attended; in most cases it was necessary to bring in additional chairs and tables to take care of the members. Recreation events had their share of devotees.

Hard times or no hard times, the total attendance, between 500 and 600, was very satisfactory, and the accommodations and arrangements seemed to meet with complete satisfaction.

It would be extremely difficult to mention the outstanding technical contributions to the meeting, but suffice it to say that the engineering papers were almost without exception of very high caliber, well above the average. The active participation in discussion was very pronounced this year.

Great credit is due the various committee members, chairmen and speakers who made the 1931 Summer Meeting the best that has ever been held by the Society.

Aeronautic Meeting Next VICE-PRESIDENTS GEORGE W. LEWIS AND ARTHUR NUTT, of the Aircraft and Aircraft-Engine Activities, have been unusually successful in formulating an attractive program for the next Aeronautic Meeting of the Society, to be held in Cleveland Sept. 1 to 3, at the time of the National Air Races. A very excellent group of technical papers are already under way, and the members of the Activities promise to stage a number of features that will be outstanding in the annals of the Society's history along aeronautic lines. This will be the 20th National Aeronautic Meeting of the Society.

It is interesting to note that the 1930 and 1931 programs of aeronautic endeavor of the S.A.E. included the holding of 56 National and Section meetings and the full presentation of 158 papers.

Wilson on Manly Board EUGENE E. WILSON, president of the Sikorsky Aviation Corp., has been appointed by President Bendix to serve for three years on the Board of Award of the Manly Memorial Medal. Associated with Mr. Wilson on this Board are Dr. George W. Lewis, Chairman, and W. L. Smith. H. M. Crane, who retires this year as Chairman of the Board, has been very helpful during the past three years in carrying on the work of this important group.

Glenn Martin Appointed PRESIDENT BENDIX has recently appointed Glenn L. Martin, president of the Glenn L. Martin Co., as a member of the Board of Award of the Wright Brothers Medal. Mr. Martin will serve for a term of three years, and with him are associated E. S. Land, Chairman, and R. H. Upson. Chairman Edward P. Warner, who retires this year from the Board of Award, merits the appreciation of the members for the excellent work he has been able to accomplish during his three years of association with the Board.

Arthur Nutt Reappointed ARTHUR NUTT, Vice-President of the Society, has been reappointed by President Bendix to continue his representation of the Society on the Guggenheim Medal Board of Judges. This appointment is for a period of four years. Other representatives of the Society on this Board are Edward P. Warner, E. S. Land and William B. Stout.

A Probationary Section in Kansas City AT A recent meeting of the Council, approval was granted to our Kansas City members for a Probationary Section of the Society with headquarters at Kansas City. The Section territory will include 28 counties surrounding Kansas City within a radius of approximately 50 miles.

For some time a very active group of members in this locality, headed by R. H. Van Ness, the new Chairman, have held a number of interesting meetings and demonstrated their eagerness to inaugurate a successful Section of the Society. The Society's 21 Sections extend their best wishes to this promising newcomer in their field.

Supplement to 1931 Handbook FOLLOWING the procedure established at the time the S.A.E. HANDBOOK OF STANDARDS AND RECOMMENDED PRACTICES became an annual publication, the new and revised specifications that were adopted by the Society at the Summer Meeting last month will be published in a separate pamphlet form as the Supplement to the 1931 S.A.E. HANDBOOK. This Supplement will be ready for distribution to the members by about the third week of this month and should be referred to in using the S.A.E. HANDBOOK so as to be sure of using the latest official recommendations of the Society.

The new and revised recommendations and a number for cancellation that were considered at the Summer Meeting of the Society were published in Section 2 of the June issue of the S.A.E. JOURNAL. All of the specifications included in the forthcoming Supplement that are not modified at the Annual Meeting next January will be included in the 1932 edition of the S.A.E. HANDBOOK, which will probably be issued the latter part of next February or early in March.

Semi-Annual Index With This Issue THIS issue of the JOURNAL consists of two sections, Section 1 being the regular monthly issue for July and Section 2 the index to Vol. XXVIII, covering the issues from January to June, 1931, inclusive. Any reader who fails to receive a copy of the Semi-Annual Index as a part of this issue of THE JOURNAL is requested to notify the Publication Department at the Society's headquarters in New York City, and one will be mailed to him.

Wind-Tunnel Tests *and* Body Design

Metropolitan Section Paper

By Julio Andrade[1]

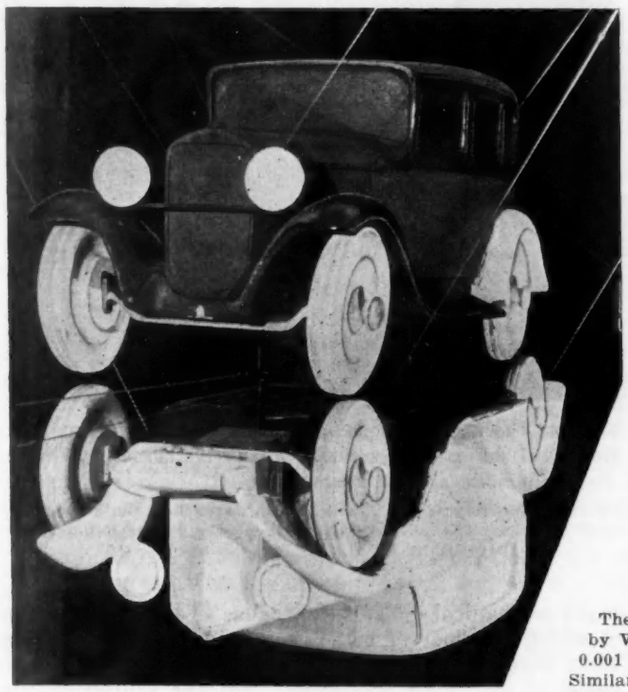


FIG. 1—METHOD OF TESTING MODELS IN WIND-TUNNEL TO SIMULATE GROUND EFFECT OF A CAR ON THE ROAD

The Model Is Hung from the Top of the Tunnel by Wires and Connected by Wires to a Registering Balance That Can Record a Pull as Light as 0.001 Lb. A Dummy That Duplicates the Under Part of the Chassis Is Similarly Supported in Inverted Position under the Test Model, so as To Give a Rectilinear Airstream along the Center Line between the Two Chassis

Wind-tunnel tests of automobile models, as made at the University of Detroit, are described, and general design of the body and fenders to reduce air resistance and produce a good appearance is discussed. The author points out that, although many air-resistance tests with automobiles have been made in Europe and the United States, the findings have not resulted in improvement of design of production cars.

The series of tests conducted at the University by the body company with which the author is connected showed that a moderately streamlined 1931 body design required 7½ less horsepower to overcome air resistance at 80 m.p.h. than was required by a 1930 body design having a smaller frontal area. This represents an increase in efficiency of nearly 13 per cent.

The methods of making the tests so as to include the ground effect and of determining the flow pattern around the car are described, as is also the method of making the test models.

With reference to public taste in design, the author concedes that the American public would not, for years to come, accept the radical streamlined bodies evolved in Europe but asserts that designs can be produced that will eliminate unnecessary air resistance, result in better utilization of the engine power and better handling of the car at great speed, and afford an opportunity to introduce novel shapes. A change in our concept of beauty in regard to the automobile is not impossible, as even the most fundamental taste of the public can be changed in a short time.

MANY air-resistance tests have been made with automobiles during the last 15 or 20 years both in Europe and in this Country. These experiments have been conducted by different methods, most of which are no longer used; but it is doubtful if any tests have been made in this Country, with the possible exception of some on racing cars, for the purpose of actually improving the streamlining of a passenger-car. Most of the tests were made for purely scientific research and without the investigator having the opportunity of putting his findings to a practical or, rather, a material purpose. Others have been made to find out the actual air resistance to a particular car but without any intention of improving the design.

This subject has received more attention in Europe than in America, some automobiles having been designed abroad in accordance with aerodynamic laws, and some of them were tested in wind-tunnels and improved as a result. But everyone must admit that, at least for some years to come, it would be impossible to sell to the American public such specimens as the pictures show, not only on account of their radical shape but also because of the great amount of wasted space and the extreme overhang of the rear end that is called for by perfect streamlining.

On the other hand, here we have millions of automobiles designed in accordance with our interpretation of the public's taste, utilizing all available space and offering all the comforts that we can produce, but without giving the least attention as to air resistance.

It seems to me that neither extreme is ideal or necessary, but that an approach to streamlining can be sought and made, not only for better utilization of the power of the engine and for the better handling of the car at great speed but also as an excuse for introducing novel shapes and to give a freer hand to the designer. I believe that something of this order has been accom-

[1] Assistant chief designer, Murray Corp. of America, Detroit.

plished in the new Reo body lines in the series of wind-tunnel tests that the Murray Corp. of America has conducted at the University of Detroit under the direction of Professor Altman.

Clay and Plaster Models Used

Two or three years ago we came to the conclusion that, to produce entirely new shapes in the automobiles we design—which, like any other object, must necessarily have three dimensions—the design should be made in three dimensions; that is, it should not only be drawn, but modeled. I do not refer to the general practice of developing a draft and then interpreting it in a wood-frame construction covered with clay instead of metal, for this necessitates conceiving the shape first in a two-dimensional plane and then transferring it afterward into the real object. Our models are made one-quarter size and no development of surfaces is made on paper for them. The surfaces and shapes are produced by the designers free-hand, not by triangulation formulas. These models are complete automobiles from bumper to bumper, as far as appearance is concerned. When circumstances demand it, we cast them in plaster of paris, for a more accurate reproduction and for exhibition. They serve three purposes: the creation and development of the design, its presentation to the executives and customers, and, now, the wind-tunnel test.

How Ground Effect Is Simulated

Virtually every present car, when moving along the ground, crowds the air under the chassis, increasing its velocity and decreasing the pressure along lines parallel to the direction of motion. This creates a cross-wind force that tends to draw the car toward the ground. On the other hand, it is possible that the particular shape of an automobile will cause the air under it to tend to lift it from the ground. This shows that we must consider the ground effect when measuring the air resistance of an automobile.

If we were to hang only the model to be tested inside the tunnel, the ground effect would be missing and the resistance measured would be incorrect. If we set the model on the floor of the tunnel, as an automobile stands on the ground, the result would not be correct either, because of the friction of the air on the floor; that is, the air flowing next to the floor would not have the same velocity as the air above the car. That this is not the case with the actual car rolling on the road is evident; in this case the car is in motion and the road friction on the air has no bearing on the problem.

Experiments have been conducted with a moving floor or belt under the model to be tested, but this has offered many mechanical difficulties because of the great speeds at which the floor or belt is required to move. As the tests were conducted at the University of Detroit, the model to be tested was hung from the ceiling of the tunnel by wires and connected by the same means to a registering balance which can record a pull as light as 0.001 lb. A duplicate dummy of the bottom part of the chassis was supported in the same way and placed upside down directly under the model, the wheels of the model and those of the dummy chassis nearly touching one another; that is, the dummy is like a mirror reflection of the model, as in Fig. 1. With this arrangement, a rectilinear airstream is obtained where the ground would be, which is the center line of the air-flow between the two chassis (See Fig. 2). This arrangement, I understand, reproduces virtually the same condition, as far as the ground effect is concerned, as that of the actual car moving along the ground.

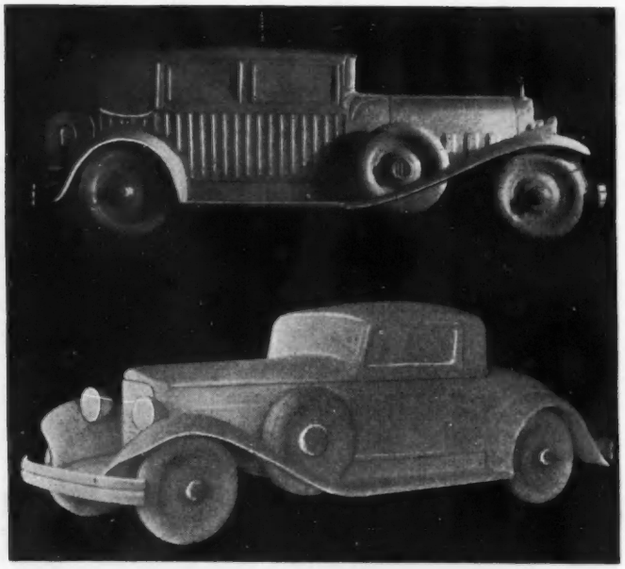


FIG. 3—CLAY MODELS OF REO FLYING CLOUD AND REO ROYALE USED FOR MAKING COMPARATIVE TESTS OF WIND RESISTANCE

Although the Royale Has More Frontal Area and the Windshield Is Wider than That of the Flying Cloud, the Power Required To Drive It at 80 M.P.H. Is Less by 7½ Hp.

Reo Royale Shows Less Wind Resistance

The first test that we made was a comparative test between last year's Reo Flying Cloud and the present Reo Royale, Fig. 3. Of the two jobs, the Royale is much the larger, the distance across the windshield on the Flying Cloud being approximately 46 in. and on the Royale nearly 50 in. In spite of this difference in bulk, the experiments showed that at 80 m.p.h. the larger car required 7½ hp. less power to overcome the air resistance than did the smaller car. To overcome the air resistance at that speed the smaller model required 60.2 hp., as against 52.5 hp. required by the new model, showing an increase in efficiency of nearly 13 per cent.

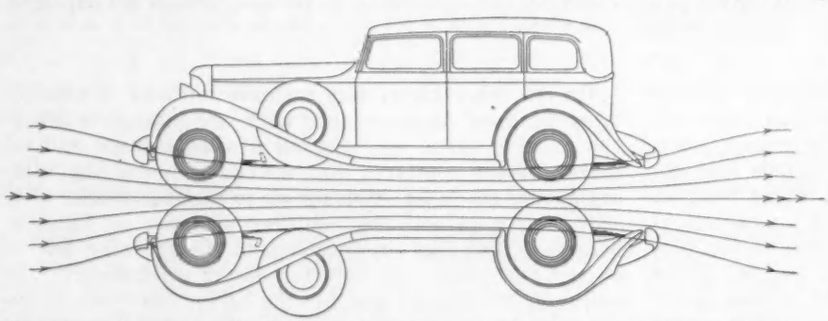


FIG. 2—DIAGRAM OF AIRSTREAM BETWEEN THE MODEL AND DUMMY SHOWN IN FIG. 1

As the air resistance of a body is proportional to the square of the velocity, and the horsepower necessary to overcome this resistance increases as the cube of the speed, the results at 60 m.p.h. are not quite so interesting, and at 40 m.p.h. are not to be considered. But at greater speeds than 80 m.p.h. the results would be still more surprising. Though it may be true that few persons would drive a passenger automobile any faster than 80 m.p.h., many automobile companies are claiming greater speeds for their cars. Therefore, testing cars for air resistance at speeds of 90 or 100 m.p.h. would only be keeping pace with the chassis designer.

How Air-Flow Pattern Is Secured

Another experiment which I believe is of much interest to the designer is the test to ascertain the flow pattern around the car. For this, a metal plate is fitted to the model along the longitudinal center-line and allowed to project several inches beyond the model all around it; or, if the model is not to be used for any other purpose, it can be cut in halves, and one-half mounted on a plate, which must project several inches from the model. The model is then mounted on a stand 12 or 15 in. high and fastened to the floor of the tunnel. This plate, which must be painted white and have a very smooth surface, is coated at the last moment with a mixture of kerosene and lampblack. The air is then turned on and drags the lampblack along in whatever directions the different shapes of the car cause the air to flow, presenting a picture in black and white of the air-flow and eddy formations around the car. By this means we can actually see, as in Fig. 4, what a particular design is causing the air to do and which parts of the car need improvement.

The first test will tell us the total air resistance in pounds at any given speed; the other test will tell us what parts of the car are causing the major resistance. The University of Detroit has now developed a solution with which the whole model can be coated so as to give a picture of the air-flow on all the parts of the model. Clay models are very quickly adaptable for this particular experiment as they can be changed or modified quickly in accordance with the flow pattern, the plate being coated over again and the test continued until a satisfactory result is obtained.

A procedure that seems advisable for those who will want to improve the streamlines of an automobile, without deviating much from lines that are regarded today as being beautiful and practical, is to first consult the expert in aerodynamics. Some of his advice may not suit the designer or the manufacturer, but the designer will acquire a knowledge of what shapes will or will not offer air resistance.

After he has modeled one side of the car in accordance with his ideas of beauty and the standards he must maintain and more or less in harmony with aerodynamic laws, he should mount it on a plate as already described and proceed with the flow-pattern test. Changes can then be made, in accordance with his judgment, on those parts of the car which the wind-tunnel expert has indicated cause various types of air disturbance. When he has gone as far as he dares with the streamlining of the shapes, he should prepare the models for the air-resistance test. I believe that a comparative test of the new and old models would be the most practical way of working out the lines, as the designer will not have to reproduce those parts that must necessarily be alike, such as the bottom of the chassis, and the results obtained will be more evident. The experiment will show the total air resistance in pounds of the two models at any speed. From this will be figured the difference in air resistance of the full-size cars and the difference in horsepower necessary to overcome this resistance.

Chassis Also Needs Attention

The important question now is how much we can streamline the shapes of our automobiles without destroying the esthetic values that we think they have now and without interfering with other qualities that they must have. To obtain perfect streamlines or even a near approach to perfection seems to me impossible, for, if this has not been done with the airplane, what hope is

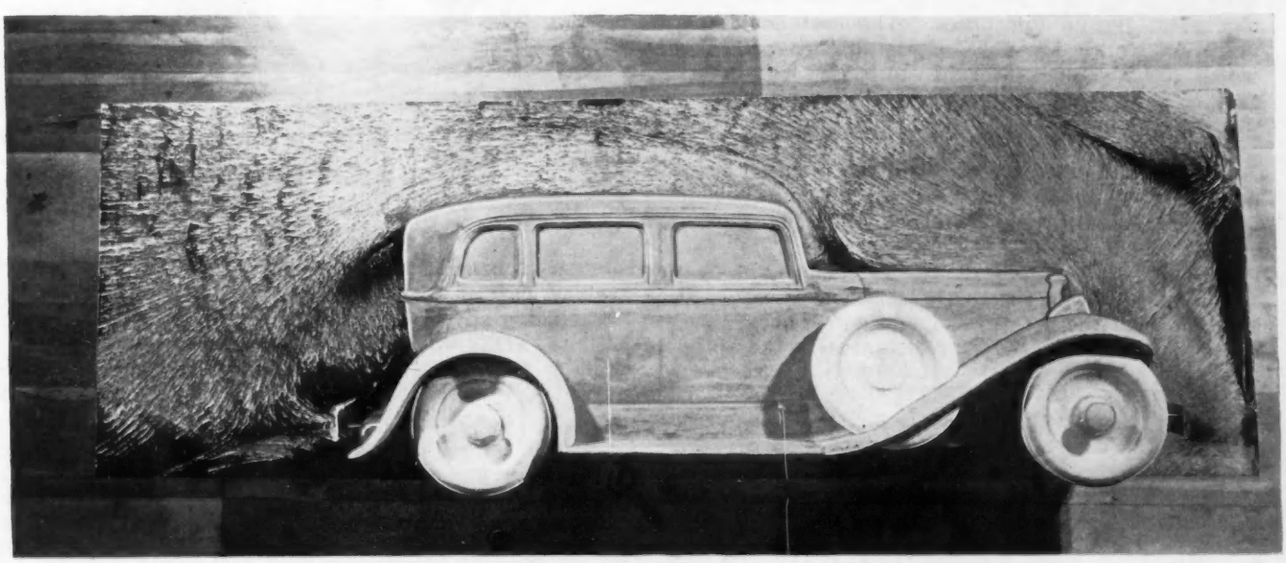


FIG. 4—METHOD OF TESTING AIR-FLOW LINES AROUND A MODEL

A Sheet-Metal Plate Is Placed along the Center Line of the Model and Extends beyond the Model in All Directions. The Model May Be Cut in Halves, One Half Being Attached to the Metal Plate. The Plate Is Coated with a Mixture of Kerosene and Lampblack and, When the Air Is Turned on in the Wind-Tunnel, the Air-Flow Drags the Mixture with It into a Flow Pattern

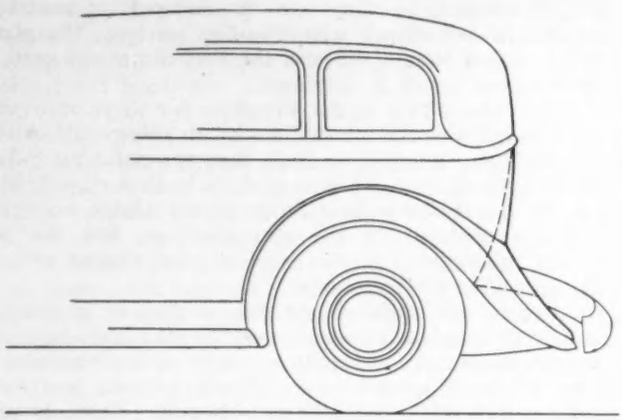


FIG. 5—TREATMENT OF REAR END OF BODY TO REDUCE EDDIES

The Rear-Panel Skirt below the Belt Line Sweeps Down over the Chassis and Takes the Form of a Small Deck. The Broken Line Indicates the Contour of the More Conventional Body

there for accomplishing it with the automobile, to which air resistance will never be as important a factor? We must enter this field with the idea of reducing only what we regard as unnecessary air resistance, keeping in mind that our product must be sold to a public of diversified taste and to which the appearance of the car is at least as important as its physical merits.

Before considering some of the improvements that could be made on the body and other sheetmetal work, it should be remembered that the chassis also offers air resistance. As long as the cooling of the engine is done in the present way, a large area of air resistance will always exist regardless of the shape of the radiator core. The bottom of the chassis could be greatly improved by covering it with a set of sheet-metal pans to decrease the road drag, the pans being made so as to afford easy access to parts that are frequently inspected. To have these pans of correct shape is very important. This is done in racing cars, and I do not see that it would offer any great design difficulties. The cost could not be objectionable in the case of the higher priced cars, which are the ones that are supposed to travel the fastest.

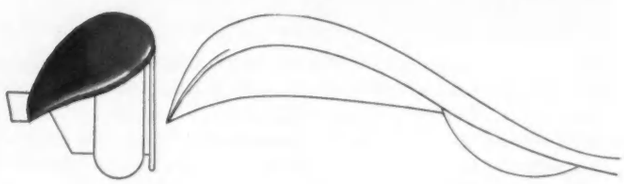
Rear-End Eddy Formation Reduced

All parts of the car can be made to offer less air-resistance, and this can be done without producing freakish effects, but it requires experimentation and good taste.

Complete streamlining of the rear end of the body is out of the question for the present, but the formation of eddies that the present shape of sedan bodies causes, which is one of the major resistances to the speed of the car, can be reduced somewhat without radical and objectionable changes if we correct the shape only below the belt line, leaving the upper back much as it is now so as not to interfere with the headroom and the rear-window opening. Rear ends have been much improved in recent years, from the standpoint of both looks and aerodynamics.

On the Reo bodies the rear panel sweeps down over the chassis, taking the form of a small deck, as in Fig. 5. The more this skirt is raised toward the belt line in the form of a deck, the more will the eddy-making resistance be reduced. I believe that this offers some possibilities because, as this skirt increases to the proportions of a deck, we can find other practical uses for it; for example, as storage space. Sedans are made in Europe with a deck large enough to enclose the spare tire, and some of them do not look bad.

The plan design of the car is as important as the side contour. All designers know that the closer the widest part of the body is to the highest part of the roof, the better appearing proportions will be attained. The widest part of the body could be moved forward without sacrificing any of the present rear-end seat space, as in Fig. 6. This would apparently reduce the width of the back, improving appearance and reducing air resistance.



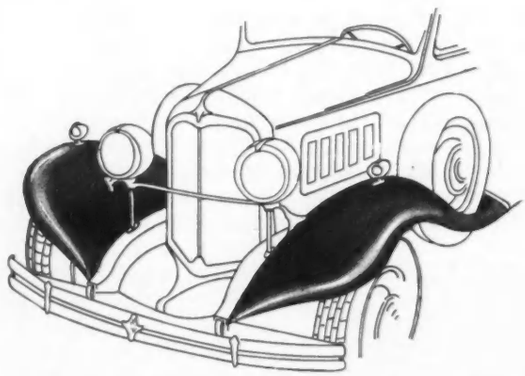


FIG. 7—EUROPEAN-TYPE FRONT FENDER THAT CONCEALS FRONT PORTION OF THE CHASSIS AND REDUCES AIR RESISTANCE

Europe has produced a very popular style of front fender that eventually we shall learn to like in this Country. The fender covers all the front mechanism of the chassis, as in Fig. 7, and though it does not give the impression of a flying wing, as ours do, it of-

(*Concluded on p. 56*)

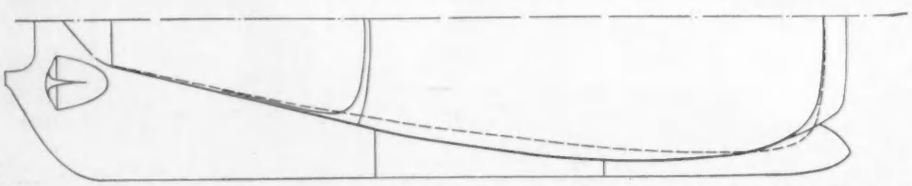


FIG. 6—HALF-PLAN-VIEW SKETCH OF SEDAN BODY SHOWING WIDEST PART AT HIGHEST POINT OF THE ROOF

This Design Reduces Air Resistance and Improves the Appearance of the Body without Reducing the Rear-Seat Width. The Broken Line Indicates the Side of the Standard or Conventional Body

Projecting the Automobile Into the Future

Annual Meeting Address

By H. Ledyard Towle[1]

The ideal way to design a car is to think ahead five or ten years.

Anything that is made to function properly has its own inherent beauty.

The public will take what is offered if you explain the reasons for making it as it is.

Personality in a motor-car means its inherent simplicity of silhouette and, in addition, the story of how it got that way.

Everything that walks or runs on the ground has its motive power in the rear. Think that over in connection with the idea of putting the motive power of the automobile in the rear.

The most advanced body and chassis engineers think that the tear-drop design will be the design of the future.

With super-highways and marginal roads around cities, normal speeds of 65 to 75 m.p.h. or more will, without doubt, be possible.

The only way to make cars in colors that will sell well is to have the manufacturer's dealers gather definite information as to colors that the public prefers.

Color right now reflects the mood of the period, but color can be overdone. We must interrupt the dark colors with light colors on suitable models.

NO ONE can tell us how to design cars to sell this year, I think, but in this connection I should like to have you think about certain fundamental principles of elementary design. Perhaps, in the hurry of living today, we are missing certain basic trends that are developing in the world. We are living in an age that later on will be called "the American Renaissance." We have passed through the period of merely developing things that will function satisfactorily and have come to the time when we are trying to beautify them.

There is much food for thought in a page in the *Ladies Home Journal*, which I was reading a few nights ago, written by Norman Bel Geddes, who is doing a great deal in the way of designing utilitarian things and changing them over completely from any accepted ideas we have of them. Mr. Bel Geddes was asked by the editor to tell what he thought would happen in the way of fundamental design and the use of materials in products 10 years hence, and he wrote in part:

> All the following prophecies will be old-fashioned 10 years from now. Aluminum will replace steel in railroad-car construction. The present railroad sleeping-car will have disappeared, and all the space will be divided into individual compartments of various sizes. Electricity will replace steam on eastern railroads extending as far as Chicago. Streets will be double-decked and divided into lanes for slow stop-off traffic and lanes for express traffic. Synthetic materials will replace the products of nature in buildings. Arc-welding will replace riveting. Airplanes will be able to land and take off vertically. Whole blocks in the midst of cities will be given over to airplane hangars, the roofs of which will form landing-fields. Exterior walls of buildings will be thin, to effect economy of space. Houses in all climates will have flat roofs. Every roof will have one or more terraces. The garage will be part of the house and will be placed on the street front. Service quarters will be at the front of the house and living rooms in the back. Mechanical devices controlled by photo-electric cells will open doors, serve meals, remove dirty dishes and cloth to the appropriate departments. Talking pictures will replace talking professors. The application of aerodynamics to automobile-body design will increase the performance per horsepower by lessening wind resistance. The engine and transmission in automobiles will be in one unit placed at the rear of the machine. The color organ will definitely take its place as a recognized medium of expression.

I wanted to cite Mr. Bel Geddes' forecast because we are immersed in the problems of today and the immediate tomorrow. The ideal way to design a motor-car, it seems to me, is to think ahead five or ten years, as Mr. Geddes has done.

Beauty in Utilitarian Design

A peculiar fact about beauty is that, when you have made a thing that functions well, behold, you have produced something that is beautiful, without having tried to do so. If we go to nature for the bases of everything, we are rather safe. The Arabian stallion

[1] A.S.A.E.—Detroit.

and the greyhound are built for speed; they function perfectly, and they are beautiful because they are so obviously suited for that specific function. You can liken them to roadsters or certain types of racing cars. The elephant, built to use his strength in various ways, can be likened to a truck or a tractor. Anything that is made to function properly has its own inherent beauty, and that is all it needs. That is something to think about when drawing moldings all over a body without thinking just what those moldings should do, if anything.

You must have been impressed at the automobile shows, as I have been, by the fact that, in general, most cars looked a great deal alike. There is no real reason for that except the fear of spending money in producing designs that the public will not like. That fear should not be, because the public will take what is offered if you explain the reasons for making it as it is. When speaking to a group of salesmen a few days ago, I tried to make them understand what I meant by "personality" in a motor-car. That means two things: its inherent simplicity of silhouette and, in addition, the story of how it got that way. It is the association of something interesting with the object.

The railroads that have tracks paralleling each other between cities awoke to the fact that travelers had no special reason for preferring one road over the other, so they began to invent personalities for their trains, giving them names, such as The Chief, to California; the Minute Man, the Twentieth Century, the Golden Arrow, from Calais to Paris; the Blue Train, from Paris to Nice; and the Flying Scotsman, from London to Edinburgh. Those trains have personality, first, because they have the individuality of names that carry an association of ideas; and, second, because they stand out in design and color, outside and inside, from other trains. They are different from other trains and that brings them business and keeps it. In New York City the Third Avenue Elevated Railroad was losing traffic to the subways and taxicabs, so the company decided to paint the trains orange and advertise the road as the "Open-Air Route"—where the garlic was less garlicky—and it won back a lot of traffic.

Public taste can be influenced very fast because of the many periodicals of all kinds, the radio and other sources of information for reaching the people quickly and guiding them in their thoughts. So, in designing automobile bodies, the designer should note what is being done in the magazines, what is said by radio and what is being said publicly, because the public is taking it all in and sooner or later will believe the things it has seen and read and heard and will be looking for expression of the ideas in the articles it buys.

Motive Power in the Rear

Everything that walks or runs on the ground has its motive power in the rear. At least, such is my own opinion based on personal observation. The horse, the dog and any animal that moves on four legs has the most strength for its motive power in its rear legs. Think that over in connection with the idea of putting the motive power of the automobile in the rear. It has been done in Germany, by Rumpler and many others. If the idea is adopted here, and it may very well happen, think what an opportunity will be afforded the designer. For one thing, drivers are objecting now to the fact that hoods are so long and the seats so low that they have to develop a seventh or eighth sense to stay on the paved road because they cannot see the side of even the right front fender.

The most advanced of the many body and chassis designers with whom I have talked here and abroad think that the teardrop design will be the design of the future. The shape will be large and spherical in front and fall away to a taper in the rear. That is the perfect aerodynamic form. The new German ship Bremen has, to all appearance, the same bow as any other ocean liner, but I am told that below the water-line she is blunt in front and fades away to the rear. In other words, she is back-frontwards, because it has been found that that shape offers less water resistance.

It is good to think that the fenders on a car are nothing but air castles and that the wheels can be hidden and become a part of the car. And it is good to think that we are going to have forced-draft ventilation, because, if we do not have to open the windows, many interesting possibilities are be-

FIG. 1—CHART OF SCALE OF RADIATION WAVE-LENGTHS

The Visible Color Spectrum Lies Near the Middle of the Scale, with the Red Rays on the Long-Wave Side and the Violet Rays on the Short-Wave Side

fore us. We can also very easily conceive that the body of the future can be heated by either hot water from the engine or electric current from a large battery or a larger generator than is now used. We can have greater speed and travel greater distances in comfort. To have a refrigerator of some kind so that a meal can be set out in the car is just as possible in the future automobile as it is impossible today. An accessory that is badly needed is a lamp or a reflector that will throw a beam to the rear for use when backing.

Average Speed To Increase Still Further

Road speeds now are, I suppose, roughly 45 to 50 m.p.h. With the super-highways and the marginal roads that are being built around cities, normal speeds of 65 to 75 m.p.h. or more will, without doubt, be possible. Then we shall have to take the big lamps off the front of the car and remove various other protruding parts and accessories, because a great deal of power is required to push those things through the air at high speed. I know of one new car that was brought out on which larger head-lamps were fitted, and at 50 m.p.h. they slowed the car down 5 m.p.h. The source of light need not be so big and the lamps do not belong in an exposed position in front. Moreover, the lamps should turn with the front wheels, because, when going around curves at great speed at night, the driver wants to see where he is going.

When thinking of the body I keep talking about the chassis and the equipment, which is right; we are realizing more than ever that the body and the chassis are a unit. I have said that, to be beautiful, a thing must be fundamentally sound as to function. In considering the car of the future, I think of the screens or grilles that have been placed in front of the radiators on many cars this year. The grille originated in the road races in Europe where the roads are rough. Many stones flew up from the cars ahead and smashed the radiators and lamps of the cars behind, so screens were put on to protect them. People looking at those racing cars thought, "That is a very low, rakish car that won such and such prizes, and among other things, it has a screen in front." So builders began to put them on passenger-cars, to serve no good purpose. The screen has no meaning, from a basic point of view in design; it is one of the things that will disappear.

Nothing very new in the upholstering of bodies was observable at the shows this winter, and I was much disappointed until I talked with one body designer, who said: "I and my men don't know anything about upholstery, so mome of us go to the furniture marts in Chicago and New York and look at what the furniture manufacturers are doing. We have found many new ways of upholstering a car." That is an idea that I think is good; go outside of your own profession and see what is being done along parallel lines. Cloth seems to be popular in furniture upholstry, and it should be, but it stains and spots too easily. Someone should invent a fabric that will not spot. If anyone can do that, I think that cloth will take its real place as upholstery fabric for cars, for it is comfortable to sit on.

Color Due to Wave-Length Variation

Color is a very nebulous thing; it does not exist as a substance. If a rose looks red, it is red because its structure absorbs all the light rays except the red rays and reflects those to the eye. A pink rose absorbs part of the red rays, and so on. Everything about color goes back to certain basic principles. In the chart of rays, reproduced in Fig. 1, the medium-length waves in the middle are the visible rays that give us the color spectrum. Progressively shorter waves on the right are the ultra-violet, Roentgen or X-rays, radium emanations and, finally, the cosmic rays discovered by Millikan. On the other side of the spectrum, as the waves become longer, we have the infra-red or heat rays, the Hertzian or electromagnetic waves, and the short and the long radio waves. These rays are all basically the same, except for wave length, and come from the same ultimate source.

Many arguments have arisen about color on automobiles, and, in his own mind, everyone's opinion on the subject is as good as the next man's. The only way to make cars in colors that will sell well to the public is to have the manufacturer's dealers gather definite information as to colors that the public prefers. A certain craftsmen's guild recently conducted a competition in which the boys in this Country made replicas of Napoleon's coach. When the plans were announced, I suggested that when each boy registered to obtain the blueprints for the coach he be asked, What color is the automobile you have at home? and, What color would you like a car of your own to be?

I thought that, being boys, they would specify red and all the bright colors, but it turned out that the good old dark blue is still in the lead with the boys, and I think that maroon was second choice, with green third. Some boys wanted red, but they were in the minority. That is interesting, because today's boys are our potential future market.

When planning colors for your cars, think about who is going to buy the cars and why. A little study of Fig. 1 will show that red has a lower wave frequency than has dark blue. We become tired of seeing a red car, because the red wave impulses are longer and therefore more intermittent, and beat into the brain through the retina of the eye with greater jar than does dark blue. But if all cars were painted dark blue, the people would become tired of that, too; our street picture would be very drab. So we must interrupt the dark colors with light colors on suitable models.

How Color Preference Is Determined

People have said to me, "How do you know that certain colors are liked in certain parts of the Country; that blue is preferred here, beige in California, and some other color in Florida? The answer can be found in this: In the City of Washington, at 8 a. m. and at 8 p. m., a number of men sit around a long table at the Weather Bureau and read telegrams and cablegrams that are coming in from all parts of the hemisphere. On the table is a large map, and they put down on the map the information in the messages—rain here, snow there, the direction and force of the wind, and so on. At a given signal the forecaster comes in and reads the whole map. From the multiplicity of the information that has been received he is able to forecast the weather for all parts of the United States.

The same principle applies to getting color information from dealers. Much of it is valuable if you can learn to interpret it; it will indicate to you what to do next. If one dealer in one part of the Country says that blue is popular, you are not sure. If another

dealer somewhere else also says that blue is popular, you begin to think it may be so; and if the same news comes from all over, you are very sure that blue should be the color of your coaches and sedans.

I think that color right now reflects the mood of the period; everything is being painted in color. The public is buying cars to last longer and is buying them in the darker colors. The right move to make is to relieve this dark trend with brighter colors in the right models at the right time. But color is all over the Country and it can be overdone. That may be one reason why we are now back to the darker colors. And this is why I say we should watch the trend of public taste as it is revealed in the periodicals, in newspapers and over the radio as regards clothing, house furnishings and other articles.

THE DISCUSSION

D. BEECROFT[2]:—The belief has frequently been expressed that, when any design is fundamentally sound, something in the nature of man makes the buying public, although not artistically educated, or at least not versed in the criticism of art, approve the design. It seems to me that the Creator put into all mankind some basic judgment of the artistic or the beautiful. I should like to hear Mr. Towle's views on that.

H. LEDYARD TOWLE:—That has been proved to be so. Let us take the Cord car as an example. It was designed with its engine and driving mechanism in front. The engineers had a reason for doing all the things they did to its radiator and to the general shape of the front. That car has been copied by many other designers, with no good reason. They have taken such as they could of the good lines that were put there honestly for a real purpose and have used them in their own cars. So there is an honest job that has received recognition by everyone, and because it was honest, it is right.

Car Design To Undergo a Revolution

CHAIRMAN L. CLAYTON HILL[3]:—One reason that all automobiles look alike is that we depend too much upon what others are doing, and, if anyone brings out a design that meets with public favor, we all copy it. Possibly one way to get new ideas is to go outside of our own field for inspiration. We might look around the furniture trade, for example, to find out how to trim automobiles, for in this field a great deal of attention has been given to comfort in upholstery, to novelty of design and, particularly in the so-called "moderne" school, to utility, simplicity and new materials.

One often hears it said that *art moderne*, more correctly termed contemporary design, is going to die quickly and that to adopt any of it for automobile design is foolish. That viewpoint seems ridiculous when one considers how such typical *moderne* masses as the Empire State, Chrysler and Manhattan Buildings dominate the skyline and architecture of New York City. Some of the newer department stores are also distinctly modernistic; banks, theaters, public buildings and apartments have started to adopt this type of design throughout the Country. This would imply that modernistic technique is going to live and is going to grow on the American public.

The so-called modernistic furniture, which was ridiculed three years ago, is beginning to appeal to the public. Its characteristics are adopted for motor-car interiors, but we shall have to introduce these novelties slowly. That is true in all developments in body design. When we wish to adopt anything that is unconventional, we must do it quietly and cautiously.

I believe that automobile engines are going to be in the rear of the cars a generation from now. Rigid-airship design is based on the principle that the air resistance is less with large end forward. Airfoils are designed on that same principle, and so are the fuselages of efficiently designed airplanes. Considerable research has been done recently on complete miniature automobile bodies or models mounted in wind-tunnels, driving air past them at high velocity. These wind-tunnel investigations invariably show that there is a tremendous depression at the rear of the car which greatly resists its forward motion. That is one of the important reasons why I believe, as Mr. Towle said, that our car bodies of the future are certainly going to have the bulbous passenger-space forward and the thinner engine-housing tapering off to the rear. It is just a question of how long it will take to educate the public to accept the changed appearance.

Driving with fuel meters on one's car to record the fuel consumption at various speeds demonstrates readily how much has to be paid in fuel consumption for the extra 5 or 10 miles in speed above 45 m.p.h. It is really astounding and impresses one with the importance of studying streamlines and wind resistance in connection with automobile design as average car-speeds increase.

Fifteen years ago every one of us would have thought it marvelous to average 45 to 50 m.p.h. in cross-country driving. Now it is customary for a large percentage of the drivers to do this as a regular habit. With the turns banked, the curves made on a large radii and adequate warning signs, the modern road has been designed so that motorists can drive at 60 m.p.h. in safety, and most of our modern cars stand up under those speeds. Consequently, I think that the body designer will have to give a lot of attention to wind resistance in the future. I think lamps are going to disappear as individual units mounted out in front of the car; they will be built into the car. We shall gradually lead the public up to this by incorporating lamps in the radiator, then in the bonnet, and, finally, the fenders into the hood and lamps. Almost before we are aware of it the whole front end of the car will be made as one streamline unit. Then some day someone is going to have courage enough to turn the seats around and push the car the other way.

High-Speed and Low-Speed Cars Advocated

G. BETANCOURT[4]:—I believe that one can go to extremes in motor-car design if he tries to copy aircraft very closely. The ideal streamline body today is that of the well-designed airship; but this craft is designed for maximum efficiency at high speeds or at cruising

[2] M.S.A.E.—Manager, New York office, Bendix Aviation Corp., New York City.
[3] M.S.A.E.—President, general manager, Dietrich, Inc., Detroit.
[4] Designer, Hudson Motor Car Co., Detroit.

speeds, which are going to be around 100 m.p.h. I do not think we want a motor-car for the average erratic human being to drive at 100 or even 50 m.p.h. on any but the open super-highway. Far more city driving than highway driving is done. I should prefer to see two different types of car: the highway car, for those who do cross-country driving mainly; and the city car. In the city we want protection, first, last and always. We want bumpers all around and good brakes. I do not believe that we want airship streamlines for the city car, because nobody would want to sit right behind a mere shell of glass and sheet metal just for the sake of reduced air resistance. The question of air resistance does not come into city driving at all. I believe that the happy medium will always satisfy the largest market.

Placing the engine in front means added safety. Everyone unconsciously wants to have a great mass in front of him as a protection in case of collision. In other words, I believe that a person feels safer if he sits halfway between the wheels than in the extreme front or rear. Most of our cars carry but two passengers most of the time. If they sit in the middle, between the two axles, as is the case at present, they feel the least motion and discomfort. If the engine were in the rear, most of the weight would fall on the rear axle when going up hill, and steering would be impaired thereby.

D. BEECROFT

Road Speeds Will Increase

JOSEPH A. ANGLADA[5]:—I must disagree with Mr. Betancourt, who suggests a maximum speed of 50 m.p.h. and using the engine as a bumper. If you observe cars that have collided, you will find that most of the damage has been caused by impact from the side or from the right or left front quarter; therefore, placing the engine in front, for reasons of safety, is not valid.

With reference to wind resistance being produced by protuberances on the sides of automobiles, I recall that several years ago, when tests of tractive effort were being made on the Berlin-Zossen high-speed electric line, the tractive effort at high speed was reduced around 5 per cent by replacing round-headed rivets on the sides of the car with flat-head countersunk rivets.

MR. BEECROFT:—I believe that we are going to use our highways in the next 10 years up to 90 and 100 m.p.h. I am not a fast driver, but I have sometimes had a car running at 102 m.p.h. I mention this merely because of the necessity for better streamlining required for these higher speeds. The wind noise is a very considerable factor at high speeds. With the vast improvement in highways, we shall get up to them rather rapidly. At the meeting of the National Safety Council in Pittsburgh last fall I was impressed to hear the road commissioners from the different States outline their plans for the next five years, which included separation of grade at crossings and other matters of that nature for safety. I think there is no question that in five to seven years the streamlining of bodies for higher speeds, and for quietness and increased safety at those speeds, will be a very imperative demand in our industry.

MR. ANGLADA:—I agree with Mr. Beecroft, but we must be careful about the rate at which we adopt radical designs. For example, the modern motorship is pleasing to the eye, because its appearance, while different from that of a steamship or sailing vessel, still resembles both because the backward-sloping large funnels and masts are retained. In mechanical structures, when a thing looks right, it generally is right, for there is usually a reason for every line and proportion, but in a structure like a ship or an automobile, we may have to add parts or lines to make it beautiful. It is not necessary to have large funnels on motorships; they are an inheritance from the old days when the more powerful ships had the greatest number of funnels. In fact, the British Navy, when calling at out-of-the-way places, used to put false stacks on its warships to impress the natives of backward countries with the power of the British Navy. In some of our modern motorships, some of the funnels are used as storerooms. It is thus evident that, to produce lines of beauty or a psychological effect, or to preserve a tradition, we are privileged to put on things or produce contours that do not serve a useful function other than that of pleasing the eye.

Advantages of Placing Engine in Rear

HERBERT CHASE[6]:—I heartily agree with the Chairman's remarks about the possibility of cars with engines mounted at the rear. One point, however, on which he did not touch and which may have a profound effect upon body design in the future is that, if the engine can be placed transversely, the space remaining for use of the passengers will be greatly increased without increasing the wheelbase. In the usual high-powered car of today the whole front half of the chassis is wasted as far as passenger carrying is concerned.

A few weeks ago D. H. Montgomery, vice-president in charge of engineering of the New Britain-Gridley Machine Co., showed me a model of a car made to scale to the proportions of a Ford chassis. This was described in *Product Engineering* for December, 1930, p. 574. It was laid out for a rear engine-mounting, the engine being placed transversely. The sides of the body came out flush with the normal running-board. The wheels were recessed into the sides of the vehicle to reduce wind resistance, and the body was made to approximately streamline form. The capacity of the body, despite the short wheelbase, was equal to that of a seven-passenger Lincoln sedan, showing the gain that can be made in respect to passenger-carrying space if the engine is placed transversely in the rear.

This is not necessarily the best way of doing the job, but it presents some advantages. Mr. Montgomery takes the view that the public has become more or less used to the streamlines of an airplane and that the step to airplane contour on an automobile will not make the car difficult to sell.

Another advantage of rear engine-mounting is that the driver will have an unobstructed view of the road.

[5] M.S.A.E.—President, Anglada Motor Corp., New York City.

[6] M.S.A.E.—Associate editor, *Product Engineering* and *American Machinist*, New York City.

As many cars are built today, a driver of moderate stature cannot see the road for 50, 100 or more feet in front of the car. This does not make for safety. If cars with rear engine-mounting come, some transitional step may be necessary to produce a body that is more nearly like the present type. Other designs are possible for cars with rear engine-mounting, and bodies that differ very little from the conventional design of today so far as external appearance is concerned. A false trunk in the rear can be used to hide an eight-cylinder V-type engine. If it is necessary to make a change to rear engine-mounting in one or two transitional steps, so far as bodies are concerned, gradually eliminating the hood in front, it is possible to follow that plan.

High Speed Safer than Low Speed

CHAIRMAN HILL:—I think there is no question that we are going to have higher road-speeds. For anyone to have predicted 10 years ago that we would be driving automobiles in the very low-priced bracket at 60 m.p.h. would have been regarded as absurd, but now we are doing it regularly and the cars are standing up under such punishment.

One other point about rear engine-position interests body designers. It enables them to provide a lower center of gravity by placing the rear cushion ahead of instead of directly over the rear axle. Under these improved conditions, body height can be reduced greatly without sacrificing head room.

I should not be surprised to see automobiles a few years hence designed with a bonnet in front and one in the rear. By progressive steps the one in the rear will grow larger and the one in front will keep shrinking until we finally arrive at the more ideal design designated as the "tear-drop" body.

MR. BETANCOURT:—About 100 persons are being killed every day in this Country by motor-cars. What will happen when we double our speeds without strengthening human character? There is a sensible limit to everything. One of our leading aircraft men has said: "The alpha and omega of human conduct is safety." If we could see 100 dead people every day on the avenue, we would be a little more hesitant about yearning for more speed. In most cases, after we get to our destination we have nothing to do that really matters; and we get home without even having seen or enjoyed the countryside. High speed, in itself, is a human weakness to be checked and not a necessity to be satisfied.

CHAIRMAN HILL:—If you subtract every one who is killed under 25 m.p.h., those who are killed by locomotives and those defying the Volstead Act, the remainder killed at high speed is relatively very low.

MR. BETANCOURT:—I do not want to be misunderstood. I have worked on airplanes and longed for speeds of 300 m.p.h., in the air; and I have driven on the highways. I am reasonably sure that I would not want my city car to look like a dirigible airship. The passengers would have no protection on the sides on account of the streamlining, which would call for considerable bulging out on the sides. If we want a car for high speed only, let us build it like an airship on wheels; if we want it mainly for transportation in the city, let us consider protection and maneuverability first; but if we are to have only one car, as the majority will, I think this must be a happy medium. Things designed in an extreme style have always had limited markets.

CHAIRMAN HILL:—I think we agree that all engineering is a compromise, but many of us contend that that compromise in this particular case is being raised constantly as each year goes by. For example, the allowable speed in Detroit has just been increased to 30 m.p.h. Michigan and several other States have no speed limit on the State highways, only ruling that motorists shall drive conservatively.

Making Color Convey Impression of Speed

MR. BEECROFT:—I should like to ask Mr. Towle if color combinations can be used to convey the idea of speed. Many automobiles seem to be static and do not have the fascination of the impression of speed. I think it is very unfortunate that they lose that quality, and I wonder if anything can be done to preserve it by color combinations, as we can alter the apparent form of the automobile.

G. BETANCOURT

MR. TOWLE:—Let me answer that in part by narrating an incident. Some two years ago, when I was in the color advisory service of the duPont company, I had to go to the proving ground and make a talk to the executive committee of the General Motors Corp. about what color would do to make automobiles seem longer and lower. That color could do this with cars was a somewhat new thought to the members. Cars had been painted various colors for many years, but had not been painted with the idea of bringing out the best points or concealing the worst ones by the proper distribution of color. So six Chevrolets were given to me to paint.

I used black to mean any dark color, white to mean any light color, and 50-per cent gray to mean any trim color. I had two sedans, two coupés and two phaetons. I tried to make three of them look as long and low as possible, which is simple. The roof, rear quarters, fenders and wheels were painted dark, and the lighter color was applied through the center. The ones I wanted to look high had the roof, rear quarters and upper panels light, the body black and the fenders and wheels light.

When the members of the committee saw them they believed that the sedan which I had painted to look long and low was actually, through some trick of building, a longer and lower car than the other sedan. So we put those two back to back, and the low-looking sedan was ½ in. higher than the other, because the tires on it were fully inflated while those on the one that seemed higher were underinflated. They measured the cars and found this was so.

The use of color to signify speed is largely a matter of the design of the car. If you have a design, for instance, that admits of a dark color over the roof, rear quarters and the deck, you can use a near color, a brighter, more up-an'-at-'em color, in the front and

calm it down and slow it up with darker colors above and below toward the rear. This gives the impression of that car leaping ahead a little, but to do that you have to depend a great deal on the basic design of the body, I think.

EDWARD P. WARNER[7]:—That question of Mr. Beecroft's can be read either way. I understand that in Detroit the policemen look with benevolence on higher road-speeds, but some of us come from a part of the Country where the force of the law still puts faith in an arbitrary speed limit. When I heard that Mr. Towle had been a camouflage artist during the war, I remembered the habit of dazzle-painting a ship so that a submarine would fire its torpedo in the wrong direction by misjudging the speed, and I hope that he was going to tell us how to make automobiles look slower than they are.

Enduring Design Has Utilitarian Purpose

H. T. WOOLSON[8]:—There is no doubt whatever as to the importance of color in the merchandising of automobiles. We have all heard of cases of models which did not sell with sufficient rapidity being repainted other colors and immediately sales were accelerated; in fact, dealers and distributors throughout the Country occasionally repaint their cars to increase sales.

JOSEPH A. ANGLADA

In regard to engine location, I believe that the automobile is, to a certain extent, the product of evolution. In the early days we had designs in which the engines were placed under the seats and in various other places in the chassis, until finally they arrived at the front. I have no doubt that within the next 10 or 15 years we shall see radical design changes, some to satisfy fads and whims; but those which endure will be made for utilitarian purposes. If the rear-engine location has that in its favor, it will become popular.

In machine design, as has been pointed out, the design that is technically correct is automatically good looking. The so-called tear-drop design in an automobile might not at first appeal to the public, but, if it is fundamentally correct, it will grow in favor and be acceptable.

Long, low, rakish hoods are in demand at present; in fact, some manufacturers make hoods longer than is necessary so that they will appeal to the artistic taste of the public. It is necessary for manufacturers to meet the public demand in this respect. No one can foretell, however, that a variation in this appearance may not sometime become acceptable.

P. J. KENT[9]:—Do color experts know of any psychology founded on scientific fact as to whether a long or a short wave-length has any bearing on the popularity of color?

MR. TOWLE:—I do not think that the long or short or any other wave-length has a great deal of bearing. Color is what we think it is, and we vary in accordance with our own bodily structure. If a man is born color-blind, he remains so all his life. If he has a medium reaction to color, he can increase that by proper study. In color, the interrupting idea is a near color. Red is a near color; so are yellow and orange. The blues and violets are far colors. The near colors can be used at the proper time on the right car to cause the public to look at it again after they have become accustomed to its silhouette.

For instance, in coloring automobiles, you have various models and their functions to consider and also your company's road picture. If a company were to paint all of its models one or two dark so-called popular colors, the road picture of that company's product would not be very impressive, because, after a person had seen two sedans in dark blue, we will say, he would not be especially conscious of eight other sedans. But if every so often a near color or brighter color-combination were deliberately used on a sedan, the overall road picture would become better. I think that if a company had a board of color strategy, just to employ certain colors for specific purposes, sales would be helped.

MR. KENT:—So it comes back to the old artist's view of colors, warmth and cold, and things of that kind, rather than any new science that has been developed.

MR. TOWLE:—I think so, because the science of color wave-lengths is that of the light spectrum, not the pigment spectrum. We are interested in the pigment spectrum, which is a little different.

Better Heating and Ventilating Desired

CHAIRMAN HILL:—Is there any good reason why we should not be comfortable in automobiles when we have a source of heat and energy under the hood that is probably warm enough to drive us out of the car if it were utilized?

MR. BETANCOURT:—I think that is a matter of common sense. If you want to keep your overcoat and overshoes on, you do not want to bring the car up to room temperature; the cooler the car is, the better and safer it is for the driver, as he will not become drowsy. The heating problem is already solved by the use of special heaters for long-distance driving in extremely cold weather.

CHAIRMAN HILL:—I have no desire to have the car brought up to room temperature, but I should like to have the temperature brought up enough so that I am reasonably comfortable on long drives. I think the same thing applies to ventilation in hot weather. Why is it that, with an engine under the hood which develops upward of 100 hp., we have to open windows and a lot of insect catchers to get the air in and out of the car when we have available a source of energy that can ventilate that body as modern buildings are ventilated?

MR. BETANCOURT:—Because it would cost a great deal to ventilate a moving vehicle scientifically without having any drafts whatever.

MR. ANGLADA:—We can use the fan to blow air past the exhaust manifold and thereby heat and ventilate the car very nicely. We can also go a step further and fit a perforated pipe across the windshield front at the bottom and melt snow and sleet off the windshield.

I should like to know whether we are going to continue to use wire wheels or are going to mount tires

(*Concluded on p. 44*)

[7] M.S.A.E.—Editor, *Aviation*, New York City.
[8] M.S.A.E.—Chief engineer, Chrysler Corp., Detroit.
[9] M.S.A.E.—Chief electrical engineer, Chrysler Corp., Detroit.

The Field for Synthetic Lubricating Oils

Semi-Annual Meeting Paper

By F. W. Sullivan, Jr.,[1] *Vanderveer Voorhees,*[2] *P. T. Oak,*[3] *and D. P. Barnard*[4]

ONE method employed in a fundamental investigation of the composition of lubricating oils as it affects the viscosity characteristics has involved the synthesis of viscous oils by polymerizing a wide range of olefins with a condensing agent, such as aluminum chloride.

Many thousand gallons of synthetic lubricating oils have been made within the last two or three years from olefins produced by cracking paraffin waxes. Details of the process have been published previously and hence are not included.

The present paper deals with the characteristics of two such oils that have been synthesized in commercial quantities. The raw materials and the process of manufacture make these more expensive than ordinary motor oils, but their temperature-viscosity characteristics make them desirable for use in transmission and steering mechanisms and in hydraulic shock-aborbers, as they are less susceptible than the usual oil to viscosity changes with changes of temperature.

Comparative data on gearshifting resistance, steering effort, viscosity at different temperatures and change in viscosity, sludge and carbon formation, and oil consumption during a 50-hr. engine test are given.

FOR several years past the laboratory with which the writers are connected has been conducting a fundamental investigation of the composition of lubricating oils, particularly as it affects the viscosity characteristics of the oils. One method employed in this work has involved the synthesis of viscous lubricationg oils from a variety of olefin hydrocarbons of different structure. In brief, it has been found that lubricants of an extremely wide variety of viscosity characteristics can be prepared by polymerizing different olefins by means of a condensing agent such as aluminum chloride.

Table 1 gives some idea of the variety of products obtained by this process, depending upon the starting material. In this table viscosity-temperature characteristics have been expressed in terms of the Dean and

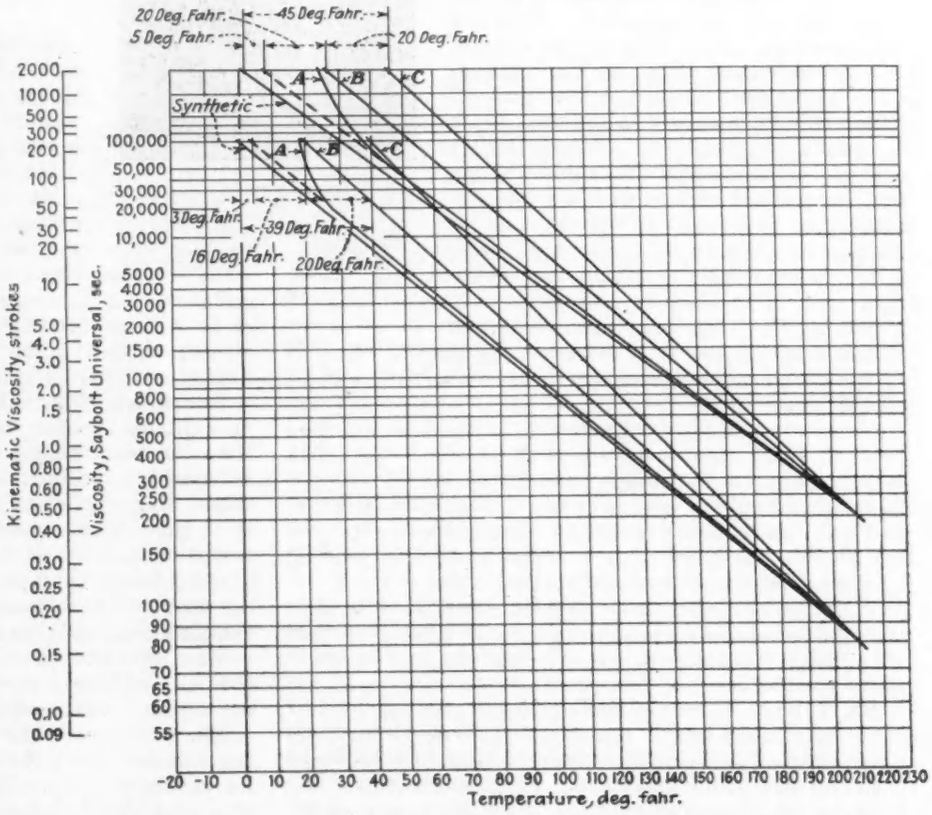


FIG. 1—VISCOSITY-TEMPERATURE CHARACTERISTICS OF SYNTHETIC OIL AND SEVERAL TYPICAL OILS AS PLOTTED ON THE MACCOULL CHART

The Effect of Viscosity Index on the Low-Temperature Limit of Oils Having the Same Viscosity at 210 Deg. Fahr. Is Clearly Shown. Oil *A* Is a Paraffin-Base Oil, and the Upwardly Curved Lines below 50 Deg. Fahr. Illustrate the Effect of Incomplete Removal of Wax upon Its Apparent Viscosity

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TABLE 1—POLYMERIZATION OF PURE OLEFINS

Olefin Polymerized	Viscosity of Product 100 Deg. Fahr. (37.8 Deg. Cent.)	Viscosity of Product 210 Deg. Fahr. (98.9 Deg. Cent.)	Yield Weight of Olefin, Per Cent	Viscosity Index[a]	Gravity, Deg. A.P.I.	A.S.T.M. Solid, Deg. Fahr.
Ethylene (C_2H_4)	2,769	80		—137.0	18.8	20
Propylene (C_3H_6)	1,083	70	33.3	20.4	33.1	—15
Butene-1 (C_4H_8)	1,654	92		50.4	34.3	—15
$CH_3=CH-CH_2-CH_3$	1,122	78	46.4			
Butene-2 $(CH_3-CH=CH-CH_3$	1,507	81	33.3	21.3	34.7	—10
Isobutylene $(CH_3)_2C:CH_2$	3,706	147	42.0	67.5		
	1,540	94			32.5	—15
	868	73				
Pentene-1 (C_5H_{10}) $CH_2=$	1,350	94	59.8	82.6		
$CH-CH_2CH_2-CH_3$	1,180	89			33.2	—20
Pentene-2 $CH_3-CH=$	1,946	93	38.5	27.4	32.8	—5
$CH_2CH_2-CH_3$	976	68	53.0			
3 Methyl Butene-1 /CH_3	3,301	109	50.8	0.0	34.0	0
	938	65				
$CH_2=CH-CH-CH_3$	321	50				
2 Methyl Butene-1 /CH_3	1,959	89	34.5	11.7	33.7	0
$CH_2=C-CH_2-CH_3$	998	68				
Trimethyl Ethylene $(CH_3)_2C:CH(CH_3)$	1,476	70		—74.5	31.0	20
	367	49	29.3			
Hexene-1 (C_6H_{12})	1,155	92		91.1	34.3	—30
Octene-1 (C_8H_{16})	905	88		104.0	34.8	—25
Cetene ($C_{16}H_{32}$)	1,774	201	85.0	138.0	33.9	40
	1,187	153			34.8	40
	717	108			35.9	35
Cyclohexene (C_6H_{10})	2,135	85		—27.6	18.0	20
Pinene (turpentine) $(C_{10}H_{16})$	4,750	83		—324.1	15.8	25

[a] The viscosity index (see Dean and Davis, 21) of each oil was calculated for viscosity of 85 at 210 deg. fahr.

Davis viscosity index[5] in which the temperature coefficient of viscosity of a purely paraffinic type of oil is designated as having a viscosity index of 100 and that of a purely asphaltic type of oil, zero.

Fig. 1 illustrates the viscosity-temperature characteristics of several typical oils as plotted on the Mac-

[5] See *Chemical and Metallurgical Engineering, Chemistry*, vol. 36, p. 618.

TABLE 2—PHYSICAL PROPERTIES OF SYNTHETIC OILS MADE FROM PARAFFIN WAX

	Oil No. 4,530	Oil No. 4,555
Gravity, deg. A.P.I.	30.6	29.7
Flash-Point, deg. fahr.	515 (268 deg. cent.)	615 (324 deg. cent.)
Pour-Point, deg. fahr.	—20 (—28.9 deg. cent.)	0 (—17.8 deg. cent.)
Viscosity Saybolt universal sec. at 100 deg. fahr. (37.8 deg. cent.)	850	3,250
Saybolt universal sec. at 210 deg. fahr. (98.9 deg. cent.)	85	197
Viscosity Index	102	102
Color, N.P.A.	2	2½
Conradson Carbon, per cent	0.13	0.4
Sligh Oxidation, mg. sludge per 10 gm. oil	1.8	2.8

TABLE 3—LIMIT OF VISCOSITY FOR EASY GEARSHIFTING

Transmission No.	Type	Maximum Viscosity Permitting 2-In. Shift with 3-Lb. Effort, Poises
1	Sliding Gear	700
2	Synchromesh	1,400
3	Internal Gear, four-speed	1,400[a]

[a] The limit for this transmission is based on the shift from third to fourth speed.

Coull chart. The effect of viscosity index on the low-temperature limit of oils having the same viscosity at, say, 210 deg. fahr., is clearly shown. The curved lines of the paraffin-base oil illustrate the effect of incomplete

TABLE 4—LOWEST TEMPERATURES AT WHICH VARIOUS LUBRICANTS WILL PERMIT SATISFACTORY GEARSHIFTING

Oil	Viscosity, in Sec., at Deg. Fahr. 100	130	210	Viscosity Index	Temperature, in Deg. Fahr., for 3-Lb. Shifting Effort in Transmissions No. 1	2	3
Synthetic	3,500	1,250	200	102	18	11	11
B	5,000	1,580	200	81	24	25	25
C	12,500	2,540	200	32	57	50	50
Synthetic	2,300	930	160	106.5	11	3	3
B	3,800	1,180	160	71	29	20	20
C	8,500	1,800	160	42	52	45	45
Synthetic	1,610	640	120	100	5	—2	—2
B	2,100	770	120	78.5	18	11	11
C	4,300	1,140	120	37	42	35	35
Synthetic	800	335	80	99	—8	—16	—16
B	925	380	80	84	0	—7	—7
C	1,550	515	80	9	23	16	16
Synthetic	245	121	50	99.5	—33	—40	—40
B	285	130	50	81	—23	—29	—29
C	380	152	50	24	—7	—13	—13

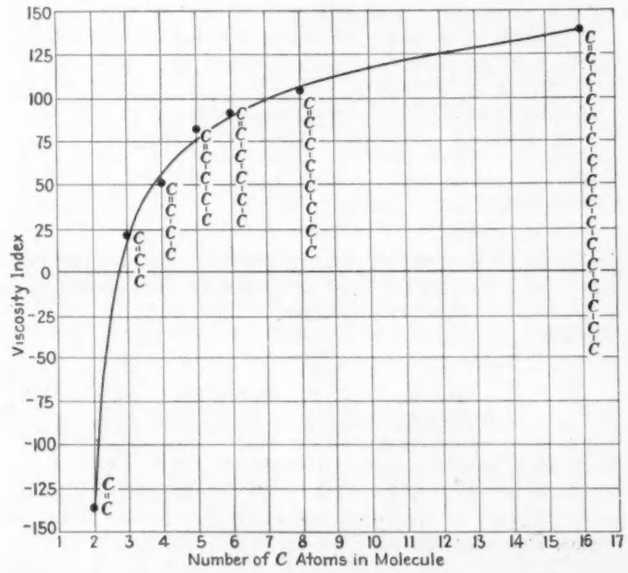

FIG. 2—EFFECT OF SATURATED CHAIN LENGTH UPON THE VISCOSITY INDEX OF OILS SYNTHESIZED FROM HYDROCARBONS OF INCREASING MOLECULAR WEIGHT

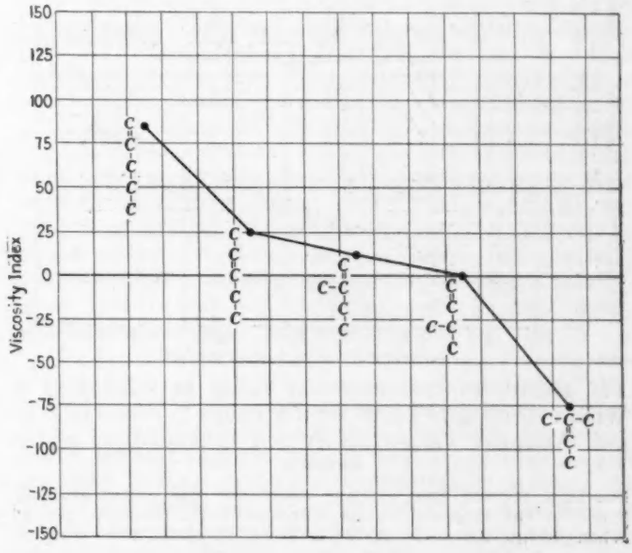

FIG. 3—EFFECT OF INTERRUPTION OF THE SATURATED CHAIN LINKAGE UPON THE VISCOSITY INDEX OF OILS SYNTHESIZED FROM ISOMERIC HYDROCARBONS

TABLE 5—PERMISSIBLE TEMPERATURES OF TYPICAL LUBRICANTS FOR LOW-TEMPERATURE STEERING EFFORT WITH CAM-AND-LEVER-TYPE GEAR

	Viscosity, in Sec., at Deg. Fahr. 100	130	210	Temperature Limit for Satisfactory Steering (50,000 Poises), Deg. Fahr.
Synthetic	3,500	1,250	200	—25
B	5,000	1,580	200	—6
C	12,500	2,540	200	22
Synthetic	2,300	930	160	—33
B	3,800	1,180	160	—9
C	8,500	1,800	160	17

TABLE 6—VISCOSITY OF HEAVY RESIDUAL OILS AT 210 DEG. FAHR. WHICH CORRESPONDS TO 50,000 POISES AT —10 DEG. FAHR.

Type of Lubricant	Saybolt Seconds
Synthetic Oil Blended with B-Type Residual	300
A-Type Residual	280
B-Type Residual	235
C-Type Residual	75

TABLE 7—COMPARATIVE VISCOSITIES OF SYNTHETIC AND TYPICAL OILS AT NORMAL TEMPERATURES

	Viscosity at Deg. Fahr. —10	70	100	130
Oil	Stokes [a]	Sec.	Sec.	Sec.
Synthetic	1,300	3,250	1,100	465
A	1,300	3,000	1,050	450
B	1,300	2,400	815	335
C	1,300	1,400	465	185

[a] Viscosities at low temperatures are expressed as kinematic viscosities in "stokes"; that is, the absolute viscosity in poises divided by the density of the oil.

removal of wax upon its apparent viscosity. This cold-test effect is chiefly responsible for channeling and has a rather marked influence on resistance at the lower shearing stresses in general. An index of more than 100, therefore, indicates an oil that changes in viscosity with temperature less rapidly than does a Pennsylvania oil, while a negative index shows greater temperature susceptibility than is possessed by a Texas-type oil. Obviously, the higher index values indicate more desirable viscosity-temperature characteristics.

It will be noted that the relatively long-chain hydrocarbon, cetene, produced the best results from this point of view, while ethylene, the smallest molecule, polymerized the worst. Figs. 2 and 3 strikingly illustrate this effect. Apparently, finished oils having the longest straight chains and a minimum of branching are the most desirable. Further development of this work has shown that materials available in quantity at the refinery may be employed for the synthesis of high-quality lubricants.

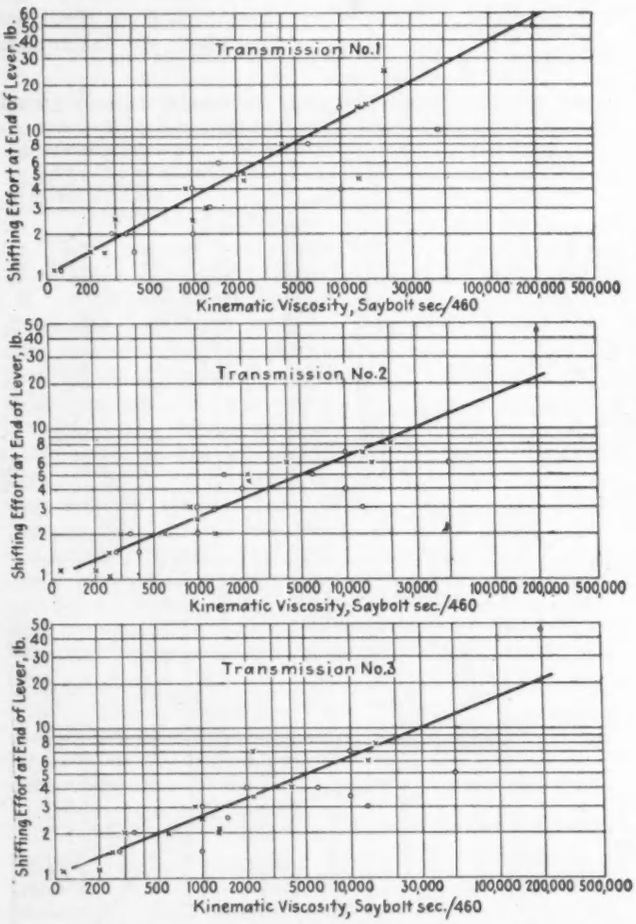
Transmission No.1
Transmission No.2
Transmission No.3
Shifting Effort at End of Lever, lb.
Kinematic Viscosity, Saybolt sec./460
0 200 500 1000 2000 5000 10,000 30,000 100,000 200,000 500,000

FIG. 4—SHIFTING RESISTANCE OF THREE TRANSMISSIONS OF WIDELY DIFFERENT TYPES WITH VARIOUS LUBRICANTS HAVING DIFFERENT VISCOSITIES AT THE TEMPERATURES OF OPERATION

The Data Showed That Shifting Resistance Was Dependent only upon the Oil Viscosity at the Temperature in Question, Except When Large Amounts of Wax Were Present. The Soap in Greases Had No Apparent Effect on Shifting Resistance but Profoundly Influenced the Tendency To Channel. Viscosity Limits for the Three Transmissions, Regardless of Actual Temperature, Were as Given in Table 3

Characteristics of Synthesized Oils

Within the last two or three years many thousand gallons of synthetic lubricating oils have been made from the olefins produced by cracking paraffin waxes. The processes involved have been described in detail in a recent paper[6] by two of the authors of this article. For the present purpose it will suffice, therefore, to present the inspection characteristics of two representative oils, as described in Table 2, that have been synthesized by this method in commercial quantities. It will be noted that the viscosity index is better for these oils than for any natural oil and yet the pour tests, which are characteristically high for natural oils of good viscosity indexes, are lower than for any natural oils of similiar viscosities.

While the raw materials employed and the complicated method of manufacture makes these synthetic oils inherently more expensive than is permissible for ordinary motor oils, many special conditions of service exist in automotive practice where temperature-viscosity

[6] See *Journal of Industrial and Engineering Chemistry*, June, 1931, p. 604.

TABLE 8—EXAMPLES OF DATA FROM COMPARATIVE ENGINE-TESTS ON A VARIETY OF OILS AT ELEVATED ENGINE-TEMPERATURES

Oil	Viscosity, in Sec., at 210 Deg. Fahr. New	50 Hr.	Acidity, Mg. KOH per Gram	Sludge, Mg. per Gram Carbon	Asphaltenes	Piston-Head Carbon, Grams	Oil Consumption, Lb. per B.Hp-Hr.
Synthetic	108	140	1.0	1.2	0.3	5.2	0.0034
A	122	195	1.9	9.3	0.8	15.0	0.0081
C	85	131	1.6	3.5	70.0	7.9	0.0052

Conditions of the Tests

Engine, air-cooled passenger-car model	
Duration of Test, hr.	50
Speed, r.p.m.	1,500
Crankcase Temperature (oil sump), deg. fahr.	275
Cylinder-Flange Temperature (average), deg. fahr.	320
Cylinder-Head Temperature (average), deg. fahr.	435

characteristics of lubricants are of major importance and higher cost is not a serious obstacle. In particular, transmission and steering mechanisms, which must respond to the application of human effort, and shock-absorbers of the hydraulic type are especially susceptible to viscosity changes. The performance of the internal-combustion engine is, to a less degree, dependent upon viscosity-temperature and cold-test properties, particularly as regards cranking in cold weather. The following summary presents some of the data obtained by the laboratory mentioned on the influence of viscosity on the behavior of some of these units and illustrates the position occupied by the synthetic lubricationg oils.

Influence of Oil Viscosity in Transmissions

An investigation of three transmissions having widely different design characteristics showed that shifting resistance, except in the case of oils chilled far below their pour-points, was dependent only upon oil viscosity at the temperature in question, as illustrated in Fig. 4. When greases were employed, the soap apparently had little or no effect on shifting resistance, although it profoundly influenced the tendency to channel.

To establish some basis for comparing the shifting characteristics of various lubricants, an arbitrary limit for easy shifting was chosen. This specified that the shift from second to high-gear positions must be realized in 2 sec. with an effort of 3 lb. at the end of the lever. The requirement of more effort or longer time to effect the shift was considered objectionable interference with manipulation of the gearset. It was found that, regardless of the actual temperature, the viscosity limits for the three transmissions were as given in Table 3. The lowest temperatures at which various typical gear lubricants will permit satisfactory shifting in these three transmissions are shown in Table 4.

It should be pointed out at this time that these data apply to oils of relatively low pour-points, as the presence of excessive quantities of wax will interfere to some extent with shifting. Pennsylvania oils are not included, as their usual high wax-content makes viscosity alone of insignificant importance at low temperatures, the characteristics being primarily those of plasticity due to the wax. Oils at temperatures appreciably below their pour-points invariably channel badly. Therefore it is impossible to make a direct comparison between oils of high wax-content and the synthetic oils which show no plastic effects whatever, even though their viscosity-temperature characteristics be not far different. Incidentally, Table 4 illustrates some of the advantages to be realized in classifying the viscosity-temperature characteristics of oils on the basis of temperatures at a fixed viscosity point, rather than the reverse system which is more generally employed. A method of indexing oils on a temperature basis is at present under investigation at the authors' laboratory, and it is hoped that the method may be described at an early date.

Steering-Gear Lubrication

Lubrication of the steering-gear presents several annoying problems. Highly viscous lubricants generally are required in order to prevent binding in some gears and clearance rattles in others. On the other hand, because of the difficulty of changing lubricants to meet weather requirements, the lubricant must interfere as little as possible with operation of the gear after the car has been allowed to stand idle at low temperatures. In the case of one particular gear upon which considerable work was done, this laboratory found that 50,000 poises represented the maximum steering effort of 170 in.-lb. at 13 deg. per sec. rotation of the steering-wheel. This value applied to the unloaded gear disconnected from the steering-gear connecting-rod. Table 5 presents the temperatures that are permissible with typical lubricants from the point of view of low-temperature steering effort.

The use of appreciably higher viscosities than those indicated in Table 5 is desirable in some cases. Viscosities above 200 sec. at 210 deg. fahr. almost invariably involve the use of heavy residual-type black oils the temperature-viscosity characteristics of which are none too good at best. If it is desired to use such a highly viscous product within the limiting conditions described, the typical oils will be found to behave about as shown in Table 6.

Shock-Absorber Fluids

One type of hydraulic shock-absorber studied in connection with this work was found to operate fairly satisfactorily with oil viscosities as high as 1300 poises. An oil to be used in cold weather should not exceed this viscosity at −10 deg. fahr., so as to avoid faulty action and even mechanical failure due to excessive stiffness. On the other hand, viscosity is a decided asset at normal temperatures, as the higher the viscosity of the lubricant which can be used is, the larger are the permissible manufacturing tolerances. General practice is to employ rather light fluids and small clearances in order to maintain a small temperature susceptibility of the instrument. Fabrication of those shock-absorbers that depend primarily upon viscous flow of the fluid can be simplified by the use of larger tolerances and fluids of high viscosity but low viscosity-temperature coefficients. Table 7 is presented to show how it is possible to secure high viscosities at normal temperatures without exceeding, for example, 1300 poises at −10 deg. fahr.

Synthetic Oils as Engine Lubricants

An important purpose underlying the development of these synthetic oils was their use for internal-combustion engines, particularly aviation engines, in which oils having good temperature-viscosity characteristics plus a high resistance to sludge formation are essential. From the point of view of combustion-chamber carbon formation, the synthetic oils do not offer quite as much advantage as would ordinarily be expected from their very low Conradson carbon tests. Their extremely low volatilities are responsible for this, but because of the almost entire absence of asphalt-forming constituents, the rate of formation of carbon in the engine is markedly slower than with conventional oils, the highly volatile Texas-type products excepted.

The engine data thus far available do indicate one highly desirable property for these synthetic oils; namely, a very low tendency to form insoluble sludge. This is particularly important in lubricants for direct-cooled aircraft engines, certain motorcoach engines and the like. Table 8 shows a few examples of the data obtained in a series of comparative tests on a variety of oils at elevated engine-temperatures. In addition, a flight service-test is in progress with one of the authors' company airplanes. While this airplane has been flown approximately 100 hr. to date using these oils, it is too

soon to draw any definite conclusions, as such a test should cover in the neighborhood of 300 hr.

To illustrate the advantages of small viscosity-temperature coefficient and low pour-points from the point of view of starting and cold-weather lubrication, one needs only to refer to work already published[7]. Improvements in viscosity-temperature characteristics obviously must be reflected in lessened interference with cranking. The pour-point is of principal interest because of its influence on the tendency of the oil to flow to the pump intake.

The synthetic oils must still be regarded as in the development stage, even though they have been produced in commercial quantities. Their principal advantages lie in the greater freedom which they allow the designer of mechanisms in which they may be employed, although their use in certain existing units may result in marked improvement in some phases of performance. Just how far their characteristics can be profitably exploited in general practice remains to be seen.

[7] See S.A.E. JOURNAL, February, 1931, p. 234, and February, 1928, p. 213, or TRANSACTIONS, vol. 23, part 1, p. 96.

Projecting the Automobile into the Future

(*Concluded from p. 39*)

on the continuously increasing diameters of the hubs. The size of the hubs, of course, has a decided effect on the appearance of a car.

CHAIRMAN HILL:—My experience in the custom-body business is that the man who spends a large sum of money for an automobile insists on wire wheels in almost 95 per cent of the cases. He does that for just one reason: he likes their appearance. In the majority of cases, when asked, he says that they make the car look lighter, and unquestionably they do.

MR. KENT:—Another answer is that they conserve natural resources. As the production of automobiles becomes greater, the wood becomes scarcer and, further, it has to be specially treated or seasoned, which requires considerable time and space in the plant. If we make wheels of metal we have ways of manufacturing the material for them and can carry production right along with the demand.

CHAIRMAN HILL:—I think that is true; however, from a sales standpoint, I believe that most persons who specify wire wheels do not know whether they are stronger or not. They buy them because they like their appearance more than that of any other type.

Another tendency that is quite noticeable in body design, particularly to anyone who has visited the foreign salons in the last two or three years, is toward making the bodies closer coupled so that, while a person sits properly and has plenty of leg room, more space is available at the rear end of the car for carrying baggage. Contact with the public at the automobile salons and shows in the last two or three years indicates an increasing demand for plenty of luggage space. Therefore the tendency to build a large luggage compartment or trunk as a unit part of the body is certainly growing.

MR. TOWLE:—In 1926, about this time of year, I made my first talk before the Society on what color could or would do to an automobile. At that time I had been impressed, in looking at the illustrations in magazines, with the fact that the artist drew much better-looking cars than the ones you might buy. The reason for that was that the artist let his artistic sense be his guide. I asked six or seven artists in New York City to draw what they thought the car of the future should be, and I showed the slides. There was considerable laughter, and everybody had a good time, but the cars we see today are reminiscent of them. The present Duesenberg particularly is almost an image of one of the designs, and there was one of a car with the engine in the rear and the driver's seat over the engine, so that the driver could look over the top of the car. Many things that those artists did that we laughed at then have come true now; so we never know where we are going.

Economic Conference for Engineers

PLANS for an economic conference for engineers, to be held from Aug. 30 to Sept. 7 inclusive at the engineering camp of the Stevens Institute of Technology in Northern New Jersey, are being perfected jointly by the engineering alumni of Columbia University and the Stevens Institute. Graduates of other universities and colleges and junior members of National engineering societies will be welcome at the camp during the conference.

Morning lectures and discussions each day will deal with "the dollar factor in engineering" or "technique in calculations involving money." An open forum and round-table discussion each evening will deal with "elements in depression—seasonal and cyclical fluctuations." The hours for lectures, conferences and discussions by leading economists and engineers are to be scheduled so as to afford full opportunity to enjoy the unusual facilities of the camp for land and water sports. The camp is located near Johnsonburg, Warren County, N. J., on the shore of a 30-acre lake in a 370-acre tract of varied topography.

A grant of $1,500 toward the expenses of the conference has been made by the Carnegie Corp. A joint conference committee has been formed on which Columbia University is represented by Prof. James K. Finch, of the faculty; Lindsay H. Welling, of A. Iselin & Co.; and Edward C. Meagher, of the Texas Gulf Sulphur Co.; and Stevens Institute is represented by Robert C. Post, of Post & McCord; Walter Kidde, of the Walter Kidde Construction Co.; and Thomas W. Kirkman, of the Kirkman Engineering Corp.

Effect of Humidity and Air Temperature on Octane Numbers of Secondary Detonation-Standards[1]

Annual Meeting Paper

By D. B. Brooks,[2] N. R. White[3] and G. C. Rodgers[4]

AFTER stating briefly the requirements that reference fuels used in determining the detonation values of test fuels should meet, the tests conducted by the Bureau of Standards to ascertain the effect that atmospheric conditions have upon the relations between the primary scale and each of a number of secondary detonation-standards are described. All tests were made with a Cooperative Fuel-Research engine having a 6:1 compression-ratio L-head. Varying the throttle opening gave the desired intensity of detonation, which was estimated by the bouncing-pin apparatus. Air-conditioning apparatus, used in previous tests, controlled the air temperature and humidity.

Four sets of secondary standards, (*a*) Michigan gasoline to which tetraethyl lead and benzol were added, (*b*) Cabin Creek gasoline with similar additions, (*c*) heptane plus benzene and (*d*) Texas Spirits plus California aviation gasoline, were compared at a number of compositions with the primary-standard scale, iso-octane and normal heptane. The results of these comparisons are presented graphically and in tables.

While the effect of air temperature was investigated on only two secondary-scales—Michigan gasoline and Texas Spirits-California aviation gasoline—the effect is inferred for the Cabin Creek gasoline plus benzol and heptane plus benzene secondary-scales, since the principal effect noted is attributable to the decreased antiknock value of benzol at higher temperatures. In the case of the first three secondary-standards investigated, normal variations in atmospheric humidity had no appreciable effect on the relation between the primary and secondary scales. Humidity had a large effect on the last secondary-scale and an apparent one on the two constituents, Texas Spirits and California aviation gasoline, hence the effect of atmospheric conditions on any materials intended for use as secondary-standard detonation-scales should be studied.

FUELS used as references in determining the detonation values of test fuels should meet a number of requirements[5]. Among these are two that are incompatible; namely,

(1) The substances should be capable of preparation in a state of very high or uniform purity.
(2) Prices of the substances should not be exorbitant.

Ordinarily, materials are not prepared in a state of high or uniform purity except at a price many times higher than that of the same material in a technical state of purity. Partly for this reason, therefore, it is advisable to obviate the incompatibility by use of primary and secondary standard-fuels for detonation rating. The primary standards must meet the first requirement, while the secondary standards must meet the second. In the case of heptane and iso-octane, the primary standards now adopted, the use of secondary standards is necessary because the visible supply of heptane of sufficient purity is very limited.

Secondary standards, while they need not meet the requirement of purity, must meet the other requirements listed in the Appendix, among these that of invariance of detonation value with conditions of test.

The work described hereinafter was planned to ascertain the effect that atmospheric conditions have upon the relations between the primary scale and each of a number of secondary detonation-standards composed of typical materials.

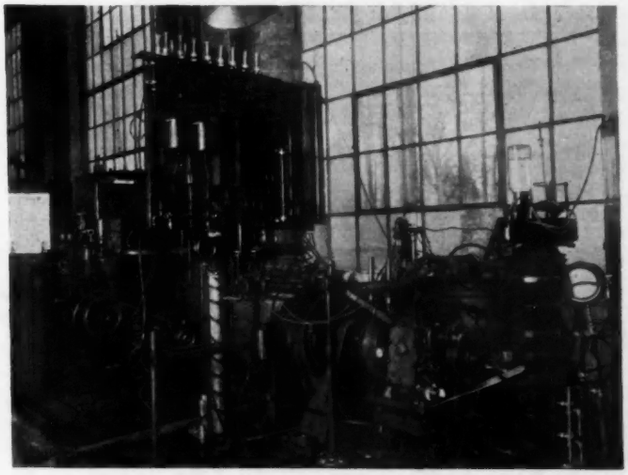

FIG. 1—ARRANGEMENT OF APPARATUS USED IN THE TESTS

The Cooperative Fuel-Research Engine with a 6:1 Compression-Ratio L-Head Was Used in All the Tests. The Throttle Opening Was Varied To Give the Desired Intensity of Detonation Which Was Estimated by the Bouncing-Pin Apparatus. Temperature and Humidity Were Controlled by Air-Conditioning Apparatus

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[5] See Appendix.

TABLE 1—CALIBRATION OF PSYCHROMETER

	Sling Psychrometer								Engine Psychrometer						Humidity of Sling Psychrometer Corrected to Engine Psychrometer Barometer		Values of $10^6 A t_1$ for Engine Psychrometer	
	Barometer		Temperatures Dry Bulb		Wet Bulb		Humidity		Barometer		Temperature Dry Bulb		Wet Bulb		Humidity					
Run No.	Mm. of Mercury	In. of Mercury	Deg. Cent.	Deg. Fahr.	Deg. Cent.	Deg. Fahr.	Mm. of Mercury	In. of Mercury	Mm. of Mercury	In. of Mercury	Deg. Cent.	Deg. Fahr.	Deg. Cent.	Deg. Fahr.	Mm. of Mercury	In. of Mercury	Mm. of Mercury	In. of Mercury	Deg. Cent.$^{-1}$	Deg. Fahr.$^{-1}$
1	753.5	29.665	16.92	62.46	12.37	54.27	8.52	0.335	750.6	29.551	60.56	141.01	26.22	79.20	8.31	0.327	8.48	0.334	662.1	367.8
2	753.5	29.665	16.79	62.22	12.27	54.09	8.46	0.333	750.6	29.551	60.29	140.52	26.14	79.05	8.29	0.326	8.43	0.332	663.9	368.8
3	753.5	29.665	16.77	62.19	12.51	54.52	8.76	0.345	750.6	29.551	60.12	140.22	26.23	79.21	8.55	0.337	8.73	0.344	662.6	368.1
4	753.5	29.665	16.73	62.11	12.47	54.45	8.73	0.344	750.6	29.551	60.07	140.13	26.16	79.09	8.43	0.332	8.70	0.343	659.1	366.2
5	753.5	29.665	16.76	62.17	12.39	54.30	8.62	0.339	750.6	29.551	59.94	139.89	26.11	79.00	8.40	0.331	8.59	0.338	662.2	367.9
											Averages		26.17	79.11	8.40	0.331	8.59	0.338	662.1	367.8

Average Value of $10^6 A_o$ = 644.9 Deg. Cent.$^{-1}$ (358.3 Deg. Fahr.$^{-1}$)
Theoretical Value of $10^6 A_o$ = 652.0 Deg. Cent.$^{-1}$ (362.2 Deg. Fahr.$^{-1}$)

Test Apparatus

The Cooperative Fuel-Research engine[6] was used in all tests, with a 6:1 compression-ratio L-head. The desired intensity of detonation was obtained by varying the throttle opening; it was estimated by use of the bouncing-pin apparatus[7]. The carbureter used was that supplied by the Ethyl Gasoline Corp. and modified for the Cooperative Fuel-Research detonation research.

Air temperature and humidity were controlled by the air-conditioning apparatus described in a previous paper[8]. The modified psychrometer employed was calibrated with a sling psychrometer. Both psychrometers were occasionally checked by the chemical-absorption method. Good correlation was obtained by use of the values $A = 0.000652$, $b = 0.00102$, in the formula

$$e = e_1 - AB\,(t - t_1)\,(1 + bt_1)$$

in which

B = barometric pressure in millimeters of mercury
e = pressure of water vapor at t, t_1 in millimeters of mercury
e_1 = vapor pressure of water at t_1 in millimeters of mercury
t = dry-bulb temperature in degrees centigrade
t_1 = wet-bulb temperature in degrees centigrade

Fig. 1 shows the apparatus as employed.

[6] See *Bulletin of the American Petroleum Institute*, Jan. 2, 1930, section 3, p. 32.
[7] See THE JOURNAL, January, 1922, p. 8.
[8] See S.A.E. JOURNAL, July, 1930, p. 56.

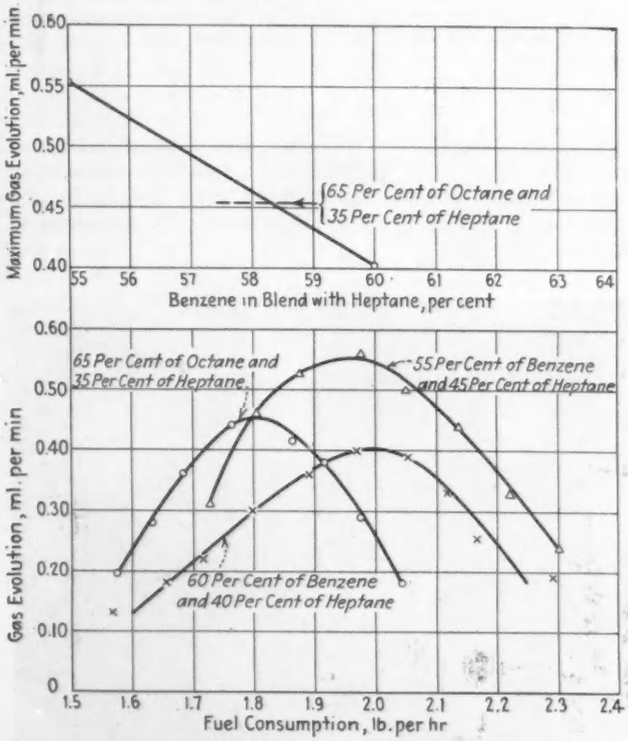


FIG. 2—TYPICAL CURVES OBTAINED IN THE CALIBRATION OF A SECONDARY-STANDARD SCALE

The Scale That Was Calibrated Was Benzene-Heptane. The Conditions Under Which These Curves Were Obtained Were Humidity, 6 Mm. (0.236 In.) of Mercury; Air Temperature, 40 Deg. Cent. (104 Deg. Fahr.); and Barometer, 764.75 Mm. (30.108 In.) of Mercury. The Complete Set of Readings for These Curves Is Given at the Right

Test Procedure

During the 1-hr. period required to warm up the engine, the wet-bulb wick of the modified psychrometer was cleaned chemically and the psychrometer was checked against a sling psychrometer, five readings being taken on each instrument. Throughout this test, the dry bulb of the engine psychrometer was kept at the temperature at which the subsequent detonation-tests were to be run. A sample series of calibration runs is given in Table 1.

After ascertaining that the bouncing-pin apparatus was working properly, 500 ml. (1 ml. = 1.000027 cc.) of the test fuel was introduced into one of the fuel

Air Temperature, Deg. Cent.	Air Temperature, Deg. Fahr.	Carbureter Setting, In.	Fuel Consumption, Lb. per Hr.	Humidity, Mm. of Mercury	Humidity, In. of Mercury	Gas Evolution, Ml. per Min.
60 Per Cent of Benzene and 40 Per Cent of Heptane						
40.02	104.04	5.00	1.568	6.2	0.244	0.130
39.68	103.42	4.75	1.655	6.4	0.252	0.180
40.18	104.32	4.50	1.715	6.2	0.244	0.220
40.42	104.77	4.25	1.797	6.1	0.240	0.300
40.42	104.77	4.00	1.891	6.0	0.236	0.360
40.22	104.40	3.75	1.969	6.1	0.240	0.400
39.94	103.89	3.50	2.055	6.2	0.244	0.390
39.82	103.68	3.25	2.116	6.3	0.248	0.330
40.18	104.32	3.00	2.167	6.2	0.244	0.255
40.22	104.40	2.75	2.291	6.1	0.240	0.190
65 Per Cent of Iso-Octane and 35 Per Cent of Heptane						
39.98	103.96	4.75	1.574	6.3	0.248	0.195
39.82	103.68	4.50	1.632	6.3	0.248	0.280
40.18	104.32	4.25	1.685	6.2	0.244	0.360
40.22	104.40	4.00	1.766	6.1	0.240	0.440
40.38	104.68	3.75	1.863	6.0	0.236	0.415
40.22	104.40	3.50	1.915	6.0	0.236	0.380
40.20	104.36	3.25	1.977	6.0	0.236	0.280
40.02	104.04	3.00	2.047	6.2	0.244	0.180
55 Per Cent of Benzene and 45 Per Cent of Heptane						
40.22	104.40	4.50	1.728	6.1	0.240	0.310
40.22	104.40	4.25	1.804	6.1	0.240	0.460
40.24	104.43	4.00	1.877	6.1	0.240	0.525
40.22	104.40	3.75	1.977	6.1	0.240	0.560
40.20	104.36	3.50	2.051	6.1	0.240	0.500
40.02	104.04	3.25	2.137	6.3	0.248	0.440
40.02	104.04	3.00	2.220	6.2	0.244	0.330
40.00	104.00	2.75	2.301	6.3	0.248	0.240
40.12	104.22	(Average)		6.16	0.243	(Average)

TABLE 2—TEMPERATURE AND HUMIDITY CONDITIONS UNDER WHICH TESTS WERE MADE

Secondary Scale No.	Air Temperature Deg. Cent.	Air Temperature Deg. Fahr.	Humidity Mm. of Mercury	Humidity In. of Mercury
1	40	104	45	1.77
	40	104	18	0.71
	60	140	18	0.71
2	40	104	45	1.77
	40	104	18	0.71
3	40	104	45	1.77
	40	104	6	0.24
4	40	104	45	1.77
	40	104	6	0.24
	60	140	6	0.24

containers and in the other fuel-container was placed a like quantity of a blend of the reference fuels known to be of greater antiknock value than that of the test fuel. While maintaining speed, humidity and other conditions constant, the throttle was then opened until a gas evolution at the rate of about 0.35 ml. per min. was obtained in the cell of the bouncing-pin apparatus with the reference blend when the mixture ratio was approximately that for maximum gas-evolution.

The mixture was then leaned until gas evolution decreased to less than one-half of the maximum value. Readings were then taken of carbureter setting, fuel consumption and gas evolution at each of from 7 to 10 points from the lean setting defined above to a rich setting likewise giving less than one-half of the maximum gas-evolution. Sample curves are reproduced in Fig. 2.

Leaving the remainder of the first reference-blend in the fuel system, the three-way cock at the carbureter was turned to admit the test fuel. A similar series of runs was then made with the test fuel, at the same throttle-opening. On completion of this series, the three-way cock was again turned to admit the reference blend. Repeat tests were then made at three mixture-ratios nearest that giving maximum gas-evolution. If the readings so obtained were within 0.04 ml. of the original values, conditions were considered sufficiently stable to proceed; otherwise search was made for the cause of the discrepancy and, when this was remedied, the two series of tests were repeated.

The first reference-blend was then replaced by a second blend, constituted so as to have poorer antiknock qualities than the test fuel, and readings were obtained, as before, at 7 to 10 mixture-ratios. Returning to the test fuel, three repeat tests were made, as before, to verify stability.

If runs were necessary with still other reference-blends to obtain maximum gas-evolution both greater and smaller than that given by the test fuel, these were then made. When the test-fuel gas-evolution versus fuel-consumption curve had been bracketed by gas-evolution curves obtained from reference blends, as in the example shown in Fig. 2, the test was terminated by a second calibration of the psychrometer.

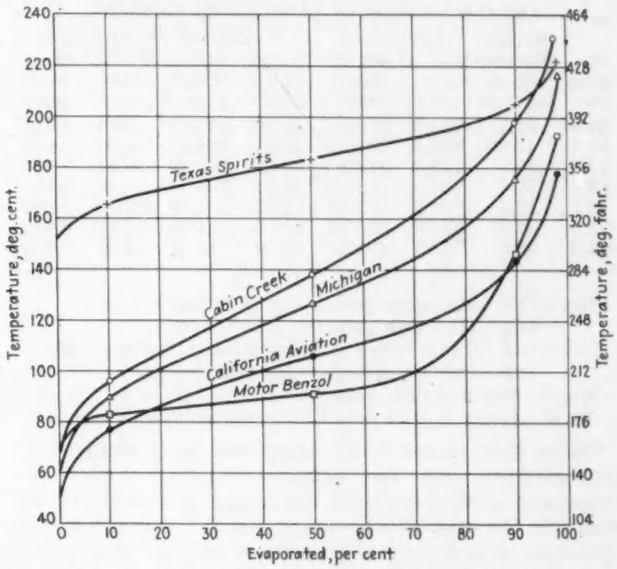


FIG. 3—DISTILLATION CURVES FOR THE VARIOUS MIXTURES USED AS SECONDARY STANDARDS

Antiknock value of the test fuel was then found in terms of the reference fuels by plotting maximum gas-evolution for the reference fuels against their composition, as in the oblique full line in the upper part of Fig. 2. The horizontal dotted line represents the maximum gas-evolution of the test fuel; the abscissa of the point of intersection is considered to represent the composition of reference fuel having an antiknock value equal to that of the test fuel.

Four sets of material, representing types believed to be suitable for use as secondary standards were tested. Distillation curves for all complex mixtures used are shown in Fig. 3. The other fuels used were normal heptane and iso-octane, supplied by the Ethyl Gasoline Corp., and benzene having a freezing point of 5.2 deg. cent. (41.4 deg. fahr.).

The four sets of secondary standards were composed as follows:

TABLE 3—BENZOL IN MICHIGAN GASOLINE

Octane No.	Benzol Equivalent, Per Cent	Barometer Mm. of Mercury	Barometer In. of Mercury	Air Temperature Deg. Cent.	Air Temperature Deg. Fahr.	Humidity Mm. of Mercury	Humidity In. of Mercury
50	39.6	753.6	29.669	40.56	105.01	45.78	1.802
66.7	59.2	750.2	29.535	40.63	105.13	45.33	1.785
75	64.1	749.6	29.512	40.48	104.86	45.44	1.789
83.3	73.0	751.5	29.587	40.54	104.97	45.32	1.784
50	43.1	749.8	29.520	40.54	104.97	18.09	0.712
66.7	58.5	755.4	29.740	40.13	104.23	18.00	0.709
75	65.7	751.2	29.575	40.21	104.38	18.37	0.723
83.3	75.4	751.2	29.575	40.97	105.75	17.83	0.702
50	40.2	757.4	29.819	59.91	139.84	18.21	0.717
66.7	57.2	756.8	29.795	59.91	139.84	18.39	0.724
75	67.7	754.8	29.716	60.08	140.14	18.73	0.737
83.3	74.7	752.9	29.642	59.84	139.71	18.38	0.724

TABLE 4—TETRAETHYL LEAD IN MICHIGAN GASOLINE

Octane No.	Tetraethyl Lead Equivalent, Ml. per Gal.	Barometer Mm. of Mercury	Barometer In. of Mercury	Air Temperature Deg. Cent.	Air Temperature Deg. Fahr.	Humidity Mm. of Mercury	Humidity In. of Mercury
21.1	0.00	749.7	29.516	40.59	105.06	45.92	1.808
35	0.94	760.2	29.929	40.37	104.67	45.72	1.800
50	2.37	752.7	29.634	39.80	103.64	46.20	1.819
60	5.85	759.4	29.898	40.42	104.76	45.64	1.797
21.1	0.00	749.7	29.516	40.63	105.13	18.39	0.724
35	1.07	752.7	29.634	40.16	104.29	18.92	0.745
50	2.32	750.2	29.535	40.12	104.22	18.52	0.729
60	4.87	749.4	29.504	41.27	106.29	18.09	0.712
35	0.99	755.7	29.752	59.74	139.53	18.32	0.721
50	2.29	758.6	29.866	59.95	139.91	18.67	0.735
60	5.33	752.5	29.626	58.98	138.16	19.57	0.770
60	5.39	757.2	29.811	57.90	136.22	19.66	0.774

TABLE 5—BENZOL IN CABIN CREEK GASOLINE

Octane No.	Benzol Equivalent, Per Cent	Barometer Mm. of Mercury	Barometer In. of Mercury	Air Temperature Deg. Cent.	Air Temperature Deg. Fahr.	Humidity Mm. of Mercury	Humidity In. of Mercury
54.6	27.7	750.3	29.539	40.59	105.06	44.81	1.764
64.7	43.7	750.3	29.539	40.51	104.92	44.61	1.756
74.8	55.3	752.2	29.614	40.22	104.40	44.81	1.764
52.5	26.7	746.4	29.386	40.17	104.31	17.35	0.683
62.9	42.1	751.3	29.579	40.33	104.59	17.33	0.682
73.4	54.3	755.3	29.736	40.17	104.31	17.70	0.697
83.8	67.6	753.3	29.657	40.30	104.54	17.07	0.672

TABLE 6—TETRAETHYL LEAD IN CABIN CREEK GASOLINE

Octane No.	Tetraethyl Lead Equivalent, Ml. per Gal.	Barometer Mm. of Mercury	Barometer In. of Mercury	Air Temperature Deg. Cent.	Air Temperature Deg. Fahr.	Humidity Mm. of Mercury	Humidity In. of Mercury
34.3	0	758.6	29.866	40.31	104.56	17.38	0.684
36.7	0	749.2	29.496	40.49	104.88	17.97	0.707
45.7	0.64	758.9	29.878	40.40	104.72	17.90	0.705
54.3	1.68	758.1	29.846	40.49	104.88	18.15	0.716
57.8	2.63	762.2	30.008	40.44	104.79	18.03	0.710
34.3	0	750.0	29.528	41.17	106.11	43.98	1.731
35.5	0	752.2	29.614	40.24	104.43	44.95	1.770
45.7	0.60	750.0	29.528	40.35	104.63	44.51	1.752
54.3	16.5	750.0	29.528	40.21	104.38	44.58	1.755
57.8	2.45	752.7	29.634	40.25	104.45	44.93	1.769

No. 1 (*a*)—Michigan gasoline plus tetraethyl lead
(*b*)—Michigan gasoline plus benzol
No. 2 (*a*)—Cabin Creek gasoline plus tetraethyl lead
(*b*)—Cabin Creek gasoline plus benzol
No. 3—Heptane plus benzene
No. 4—Texas Spirits plus California aviation gasoline

These four scales were compared at a number of compositions with the primary-standard scale, iso-octane and normal heptane, the comparison being direct except in the case of Secondary No. 2. The latter was compared directly with Secondary No. 1, which had been calibrated previously against iso-octane and heptane.

Tests on the various secondary-scales were made at air temperatures and humidities approximately as given in Table 2.

Discussion of Results

Secondary Scale No. 1 (Michigan gasoline plus tetraethyl lead or benzol).—The results of three series of direct comparisons of this secondary with the primary scale at three sets of atmospheric conditions are shown in Fig. 4. Results and test conditions are listed in Tables 3 and 4.

From the chart at the left the effects of variations in atmospheric conditions over the range explored on the relation between the benzol-Michigan secondary-scale and the primary scale are seen to be slight. It is very apparent, however, that the line representing the results obtained at the higher air-temperature, 60 deg. cent. (140 deg. fahr.), has a greater slope than those for the results at 40 deg. cent. (104 deg. fahr.). This is in agreement with other observations indicating a loss of relative antiknock value for benzol at increased temperatures. It may be said parenthetically that "relative antiknock value" is herein used with reference to the primary standard. The fact is recognized that if detonation be referred to a datum other than the Octane-Number scale, then the detonation represented by a given octane number may vary with humidity, temperature and other conditions. Conversely, invariance of relative antiknock value, as defined herein, does not preclude variation in absolute detonation when the latter is defined with reference to any datum other than the Octane-Number scale. Failure to recognize this relativity of detonation measurements has resulted in no small amount of confusion.

That the slopes of the lines representing data taken at 40 deg. cent. (104 deg. fahr.) are nearly equal indicates absence of effect of humidity on the relative antiknock values of the benzol and Michigan gasoline. The vertical displacement between these two lines may be due to change in uncontrollable engine conditions.

From the chart at the right it appears that, within

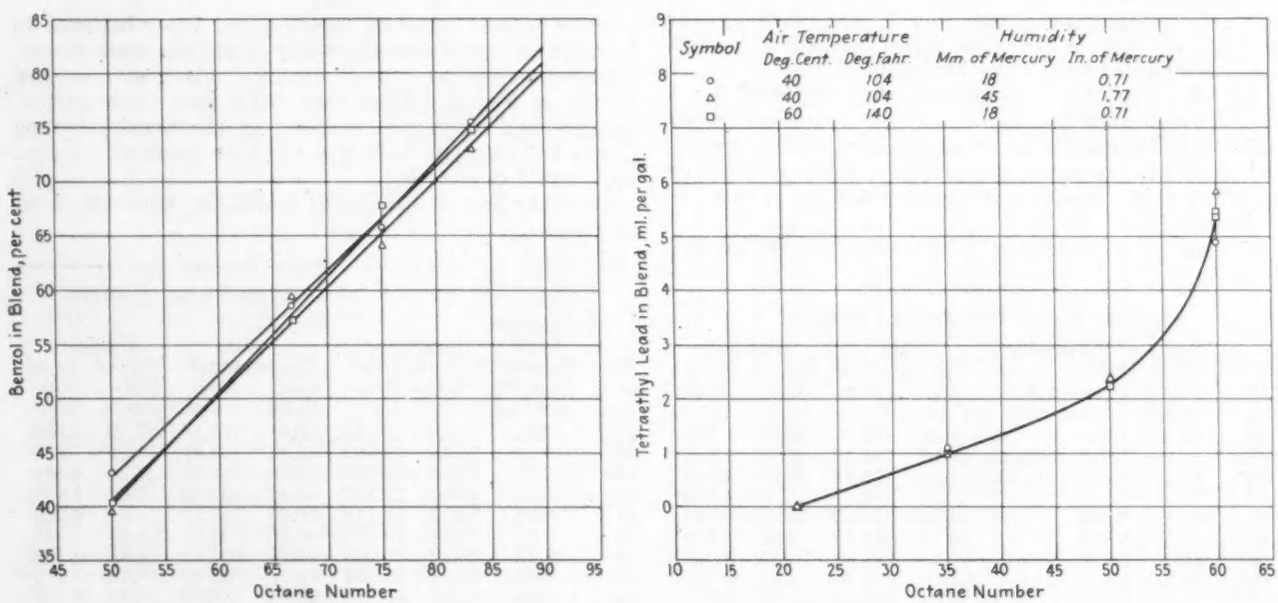


FIG. 4—COMPARISON OF RESULTS OBTAINED BY COMPARING MICHIGAN GASOLINE WITH ISO-OCTANE AND NORMAL HEPTANE
The Chart at the Left Is for the Addition of Benzol to the Gasoline and That at the Right Is for the Addition of Tetraethyl Lead

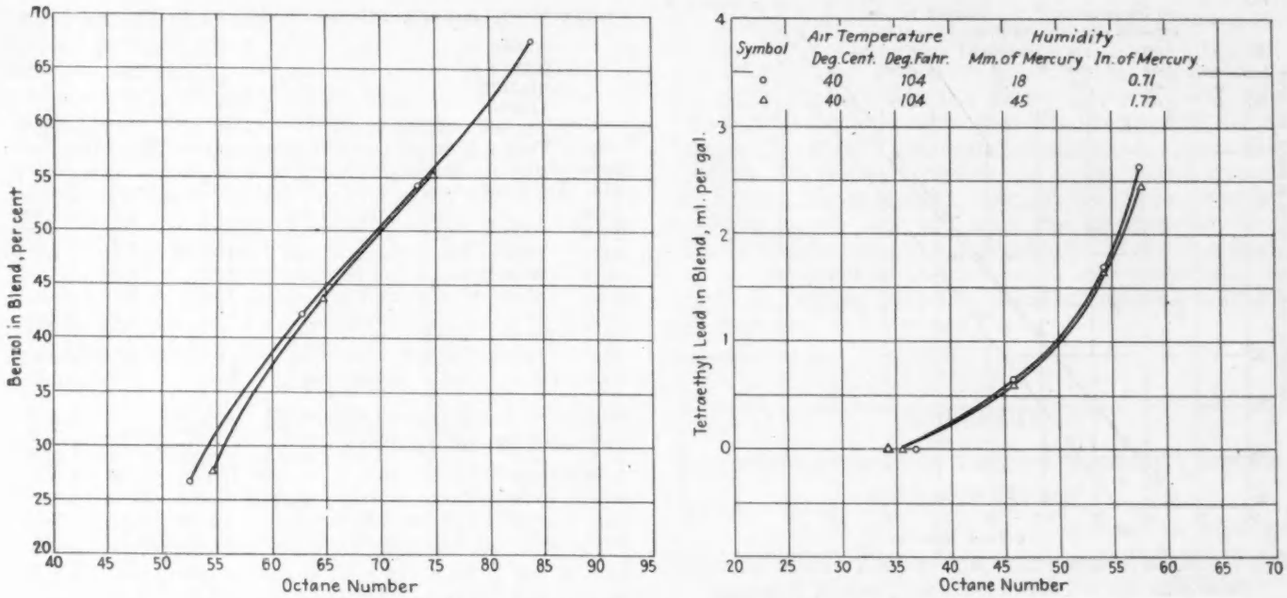


FIG. 5—A SIMILAR COMPARISON FOR CABIN CREEK GASOLINE

These Results Were Obtained by Comparing This Fuel with the Michigan Gasoline of Fig. 4 Which Had Previously Been Calibrated against Iso-Octane and Normal Heptane

the range explored, neither air temperature nor humidity has an appreciable effect on the relative antiknock value of tetraethyl lead in Michigan gasoline or of Michigan gasoline alone.

Secondary Scale No. 2 (Cabin Creek gasoline No. 3 plus tetraethyl lead or benzol).—The results of two series of indirect comparisons of this secondary with the primary scale, at 40 deg. cent. (104 deg. fahr.) and 18 and 45 mm. (0.709 and 1.771 in.) of mercury humidity, are shown in Fig. 5. Results and test conditions are listed in Tables 5 and 6.

Both charts indicate a reduction in the quantity of antiknock agent required to bring the Cabin Creek gasoline up to a given octane number at increased humidity. The consistent differences between the curves for low and for high humidities tend to discount chance as the cause. The remaining possibilities are change in uncontrollable engine conditions or an increase in the relative antiknock value of the secondary scale with increasing humidity.

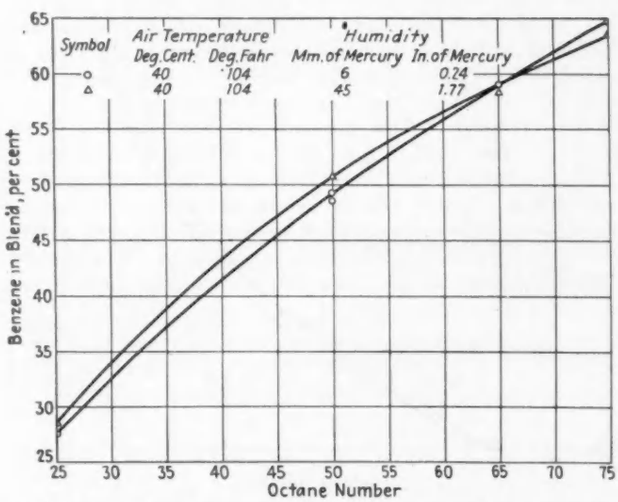


FIG. 6—COMPARISON OF HEPTANE PLUS BENZENE WITH ISO-OCTANE AND NORMAL HEPTANE

This Comparison of the Two Standards Was Made Directly

Secondary Scale No. 3 (Normal heptane plus benzene).—The results of two series of direct comparisons of this secondary with the primary scale, at 40 deg. cent. (104 deg. fahr.) and 6 and 45 mm. (0.236 and 1.771 in.) of mercury humidity, are shown in Fig. 6. Results and test conditions are listed in Table 7.

While the maximum difference between the two curves nowhere exceeds 2 per cent of benzene, the fact that repeat tests at Octane Number 50 checked original values within 0.8 per cent of benzene in one case and within less than 0.1 per cent of benzene in the other seems to indicate a definite effect of humidity, an increase in humidity apparently increasing the antiknock effectiveness of benzene and possibly decreasing that of the heptane.

Secondary Scale No. 4 (Texas Spirits plus California aviation gasoline).—The results of three series of comparisons of this secondary scale with the primary scale, at 40 deg. cent. (104 deg. fahr.) and humidities of 45 and 6 mm. (1.771 and 0.236 in.) of mercury and at 60 deg. cent. (140 deg. fahr.) and 6 mm. (0.236 in.)

TABLE 7—BENZENE IN HEPTANE

Octane No.	Benzene Equivalent, Per Cent	Barometer Mm. of Mercury	Barometer In. of Mercury	Air Temperature Deg. Cent.	Air Temperature Deg. Fahr.	Humidity Mm. of Mercury	Humidity In. of Mercury
25	27.5	754.0	29.685	40.02	104.04	6.56	0.258
50	49.3	764.5	30.098	40.09	104.16	6.45	0.254
50	48.5	758.5	29.862	40.21	104.38	6.62	0.261
65	59.0	764.8	30.110	40.13	104.23	6.20	0.244
75	64.8	764.8	30.110	40.10	104.18	6.27	0.247
25	28.5	751.6	29.590	40.51	104.92	44.63	1.757
50	50.7	750.9	29.563	40.19	104.34	44.46	1.750
50	50.7	758.5	29.862	40.34	104.61	44.65	1.758
65	58.5	750.9	29.563	40.23	104.41	44.53	1.753
75	63.9	753.1	29.650	40.22	104.40	44.62	1.757

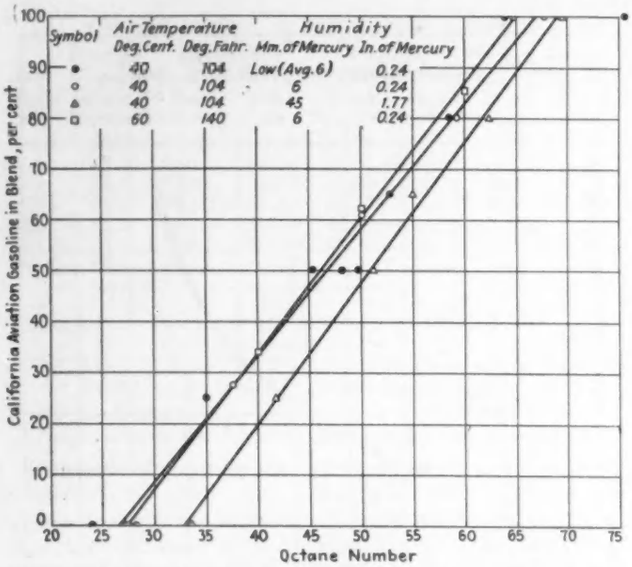


FIG. 7—TEXAS SPIRITS PLUS CALIFORNIA AVIATION GASOLINE COMPARED WITH ISO-OCTANE AND NORMAL HEPTANE

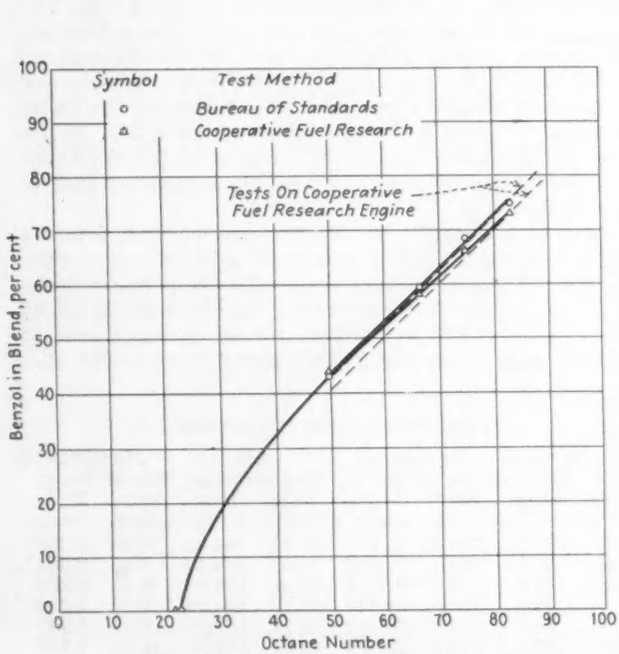
This Was Also a Direct Comparison

of mercury humidity, are shown in Fig. 7. Results and test conditions are listed in Table 8.

While in the three cases previously presented the effect of humidity has been so small as to be difficultly separable from accidental errors, but little doubt is left as to the reality of the effect shown in Fig. 7. The increase of humidity from about 6 to 45 mm. (0.236 to 1.771 in.) of mercury apparently increases the octane-number value about 6 units at the lower end and probably 2 units at the upper end of the scale. There is some uncertainty as to the octane numbers at the upper end of the scale, as the engine was of necessity running at full throttle and did not function as satisfactorily as at lower throttle. This is believed to account for the deviation of one of the low-humidity values of 100-per cent California aviation gasoline from the mean

TABLE 8—CALIFORNIA AVIATION GASOLINE IN TEXAS SPIRITS

Octane No.	California Aviation Gasoline in Texas Spirits, Per Cent	Barometer Mm. of Mercury	Barometer In. of Mercury	Air Temperature Deg. Cent.	Air Temperature Deg. Fahr.	Humidity Mm. of Mercury	Humidity In. of Mercury
24.0	0.0	764.8	30.110	40	104	6.50	0.256
35.0	25.0	756.6	29.788	40	104	8.50	0.335
48.2	50.0	773.4	30.449	40	104	2.20	0.087
49.7	50.0	756.6	29.788	40	104	8.50	0.335
52.7	65.0	756.6	29.788	40	104	8.50	0.335
58.5	80.0	749.0	29.488	40	104	7.50	0.295
75.7	100.0	764.8	30.110	40	104	6.50	0.256
45.3	50.0	758.0	29.842	40	104	2.50	0.098
64.0	100.0	743.4	29.268	40	104	2.75	0.069
33.5	0.0	741.0	29.173	40.31	104.56	44.75	1.762
41.6	25.0	743.9	29.287	40.37	104.67	44.79	1.763
51.2	50.0	743.9	29.287	40.18	104.32	44.86	1.766
54.9	65.0	741.0	29.173	40.32	104.58	45.08	1.775
55.0	65.0	743.9	29.287	40.38	104.68	44.94	1.769
62.4	80.0	743.9	29.287	40.30	104.54	44.83	1.765
69.5	100.0	743.9	29.287	40.28	104.50	44.87	1.767
28.1	0.0	749.7	29.516	40.05	104.09	5.96	0.235
37.5	27.5	749.8	29.520	40.08	104.14	5.88	0.231
50.0	60.9	754.0	29.685	40.09	104.16	5.92	0.233
59.3	80.0	768.5	30.256	40.36	104.65	5.57	0.219
67.8	100.0	768.9	30.272	40.13	104.23	5.63	0.222
	Average	758.2	29.850	40.14	104.25	5.79	0.228
27.4	0.0	768.3	30.248	60.57	141.03	5.48	0.216
40.0	34.1	752.0	29.606	59.95	139.91	5.95	0.234
50.0	61.8	752.0	29.606	59.89	139.80	5.92	0.233
60.0	85.4	751.4	29.583	59.94	139.89	5.83	0.230
64.8	100.0	745.5	29.350	60.00	140.00	6.11	0.241
	Average	753.8	29.677	60.07	140.13	5.86	0.231



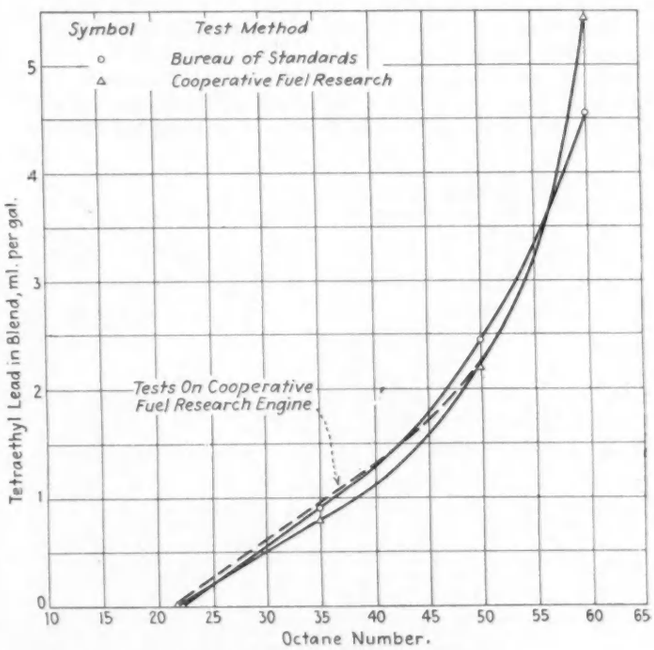


FIG. 8—ANOTHER COMPARISON OF MICHIGAN GASOLINE WITH ISO-OCTANE AND NORMAL HEPTANE

The Chart at the Left Is for Benzol Additions; That at the Right for Tetraethyl Lead. These Results Were Obtained on Another Engine in Connection with a Series of Tests To Discover Any Inherent Differences between the Regular Cooperative Fuel Research Fuel-Matching Procedure and That Described in the Paper

curve. The scattering of the octane-number values of the 50-per cent blend at low humidity is attributed to trouble experienced with the carbureter at that time.

Apparently, an increase of humidity of roughly 40 mm. (1.575 in.) of mercury increases the antiknock value of both the Texas Spirits and the California aviation gasoline, the former more so than the latter. By comparing the curve for results at 40 deg. cent. (104 deg. fahr.) and 6 mm. (0.236 in.) of mercury humidity with that for 60 deg. cent. (140 deg. fahr.) and 6 mm. (0.236 in.) of mercury humidity, air temperature appears to have little effect on the detonation of Texas Spirits but decreases the antiknock value of California aviation gasoline much as it does that of benzol.

Conclusions

That lack of time prevented investigation of the effect of air temperature on any but the first and last secondary-scales studied is to be regretted. However, since the principal effect noted is attributable to the decrease in antiknock value of benzol at higher temperatures, inferring a similar effect in the case of the Cabin Creek-plus-benzol and the heptane-plus-benzene secondary-scales would be reasonable.

TABLE 9—COMPARISON OF TEST METHODS

Octane No.	Benzol Equivalent, Per Cent		Tetraethyl-Lead Equivalent, Ml. per Gal.	
	Test Method		Test Method	
	Bureau of Standards	Cooperative Fuel Research	Bureau of Standards	Cooperative Fuel Research
22.0	...	0	...	0
22.2	0	...	0	...
35.0	...	...	0.90	0.79
50.0	43.0	43.5	2.45	2.20
60.0	...	...	4.51	4.94
66.7	59.2	58.1		
75.0	68.6	66.2		
83.3	74.9	73.0		

While the data presented in the charts of Fig. 8 and Table 9 were results of tests on another engine, undertaken primarily to discover any inherent differences between results obtained by the regular Cooperative Fuel-Research fuel-matching procedure[9] and those obtained by the procedure herein described, Fig. 8 serves to illustrate the variations to be expected in absence of control of air temperature and humidity. In the case of these tests, air temperature varies from about 20 to 40 deg. cent. (68 to 104 deg. fahr.) and humidity from about 8 to 22 mm. (0.315 to 0.866 in.) of mercury. However, the results shown at the left lie practically within the dotted lines representing results on the Cooperative Fuel-Research engine at 40 deg. cent. (104 deg. fahr.) and 18 and 45 mm. (0.709 and 1.771 in.) of mercury humidity. Those shown in the other chart are likewise close to the dotted line.

Had this investigation been terminated at the completion of work on the third secondary-scale, the conclusion undoubtedly drawn would be that normal variations in atmospheric humidity were without appreciable effect on the relation between the primary and secondary scales. However, in view of the large effect of humidity on the last scale used and its apparent effect on both constituents of the secondary, studying the effect of atmospheric conditions on any materials intended for use as secondary-standard detonation-scales will evidently be necessary.

APPENDIX

Ideal Requirements for Primary-Standard Fuels for Antiknock Testing[10]

The selection of a pair of substances as primary standards of antiknock value must be guided by certain criteria, among which the following are considered to be preeminent:

(1) The substances should be capable of preparation in a state of very high or uniform purity. The degree of purity of each substance should be susceptible of exact measurement.

(2) The antiknock values of the substances should be invariant with conditions of measurement, particularly temperature, and with age.

(3) The volatilities of the components should be identical and should be in the temperature range corresponding to the mean volatility of gasolines. The first portion of this criterion is regarded as being essential, in order that no possibility shall exist for the selective evaporation of one component, as this would result in the composition of the vaporized charge differing from that of the primary fuel-mixture supplied.

(4) The antiknock value of the more detonating substance should be less than that of the poorest fuel likely to be encountered; that of the less detonating substance should be greater than that of the best fuel normally tested.

(5) Neither substance should be such as to enhance corrosion or deterioration of the engine, nor should either induce preignition or any other unusual or non-uniform operation.

In addition, the following are considered desirable although deemed non-essential:

(6) The air-fuel ratio giving maximum detonation should be the same for the two substances. Preferably this ratio should be approximately the same as that for normal gasolines.

(7) The densities and viscosities of the two substances should be equal to those of normal gasolines.

(8) Prices of the substances should not be exorbitant.

[9] See S.A.E. JOURNAL, July, 1929, p. 80.

[10] Extract from memorandum to British Engine Testing Committee on The Problem of Primary-Standard Fuels for Antiknock Testing.

Jacket and Cylinder-Head Temperature Effects upon Relative Knock-Ratings

Annual Meeting Paper

By Graham Edgar[1]

DATA that were obtained while investigating some of the variables affecting the relative antiknock values of certain fuels are presented to show that if one condition of knock testing is varied, at least one other condition must also be varied. Increasing the jacket temperature necessitates increasing the knock intensity, decreasing the throttle opening or the compression ratio or retarding the spark.

Two sets of tests were run. One consisted in adding tetraethyl lead or crude benzene to one of the six test fuels to make it equal in knock intensity to each of the other five. In the other series the quantities of tetraethyl lead that must be added to a straight-run Mid-Continent gasoline to give knock ratings equal to different percentages of chemically pure benzene in the same fuel were determined. The results of both series, which led to somewhat opposing conclusions, are presented in tables and charts, and a possible explanation of this confiict is given.

From these tests the author concludes that (*a*) changes in jacket temperature definitely affect the relative antiknock value of fuels, (*b*) when comparing benzene and tetraethyl-lead blends with a fixed spark-advance the results obtained at different compression-ratios will differ, (*c*) adjusting the spark-advance for maximum power minimizes compression-ratio variations and (*d*), although all results may be functions of the cylinder-head temperature alone, the data are not sufficiently complete to be regarded as conclusive.

IN varying any one condition of knock testing we must vary at least one other condition. Thus, if we increase the jacket temperature, we must increase the knock intensity, decrease the throttle opening or the compression ratio or retard the spark. Since varation in almost any condition of test *may* affect knock rating, any set of data must be analyzed carefully to determine more than qualitatively the effect of a particular variable.

The data discussed herein were obtained in the course of an investigation of some of the variables affecting the relative antiknock values of certain fuels. The measurements have been taken over about a year's time, and several different operators have participated in securing them.

The Cooperative Fuel-Research variable-compression engine has been employed throughout at 600 r.p.m. The bouncing-pin method of equating fuels has been used exclusively. The knock intensity has been kept as nearly constant as the operators could judge, a fairly

[1] M.S.A.E.—Director of research, Ethyl Gasoline Corp., New York City.

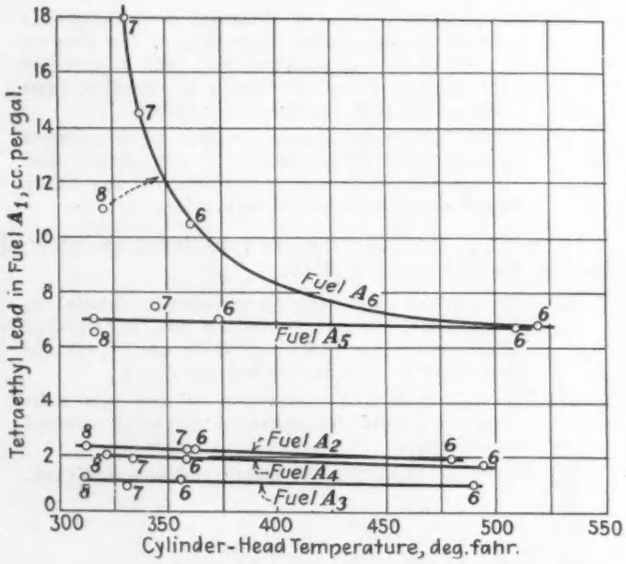


FIG. 1—TETRAETHYL-LEAD ADDITIONS TO FUEL *A*, TO EQUAL THE KNOCK RATING OF OTHER FUELS

The Quantity of Lead Added Is Plotted against the Cylinder-Head Temperature Which Varied with the Compression Ratio Which Is Indicated by the Numbers Opposite the Points on the Different Curves. The Spark Setting Was That for Maximum Power

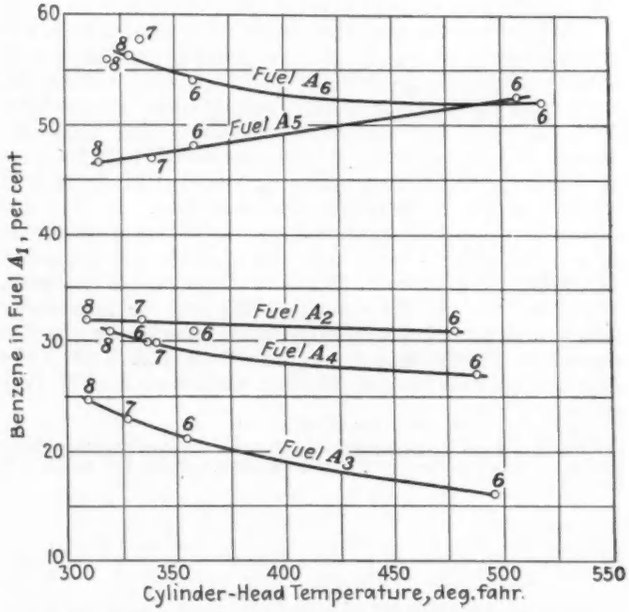


FIG. 2—BENZENE ADDITIONS TO FUEL A_1 TO EQUAL THE KNOCK RATING OF OTHER FUELS

The Method of Plotting These Curves Is the Same as That Used in Fig. 1 for Tetraethyl Lead

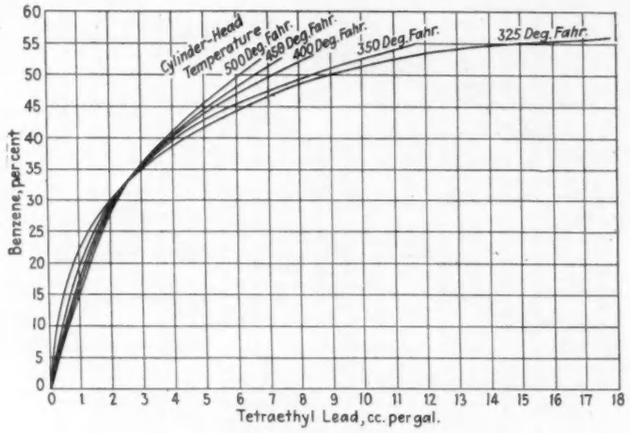


FIG. 3—TETRAETHYL LEAD-BENZENE EQUIVALENTS FOR FUEL A_1 AT VARIOUS CYLINDER-HEAD TEMPERATURES

The Equivalents Were Taken from the Curves of Figs. 1 and 2 and Plotted as a Function of the Cylinder-Head Temperature. At High Cylinder-Head Temperature Tetraethyl Lead Is a Relatively More-Efficient Antiknock Agent than Benzene. The Spark Was Set To Give the Maximum Knock

sharp knock being employed. The air-fuel ratio has always been that for maximum knock.

The data may be divided into two parts, and, since the two parts lead to somewhat opposing conclusions, they will be treated separately. A possible explanation of the conflicting results will be indicated at the conclusion.

Experimental Method

Part 1—The fuels employed were the committee Fuels A_1, a straight-run Pennsylvania gasoline; A_2, a benzol blend; A_3, an aviation gasoline; A_4, a California gasoline; A_5, a leaded gasoline, and A_6, a cracked gasoline.

TABLE 1—BENZOL AND TETRAETHYL-LEAD ADDITIONS TO FUEL A_1 TO EQUAL OTHER FUELS

Fuel	Jacket Temperature, Deg. Fahr.	Compression Ratio	Throttle Opening, Deg.	Cylinder-Head Temperature, Deg. Fahr.	Spark-Advance, Deg.	Benzol Added, Per Cent	Lead Added, Cc. per Gal.
A_2	212	8 to 1	12.0	311	6.0	32.0	2.30
	212	7 to 1	17.5	335	11.0	32.0	2.20
	212	6 to 1	24.0	359	14.0	31.0	2.20
	340	6 to 1	16.5	478	3.0	31.0	1.95
A_3	212	8 to 1	11.5	310	6.0	24.5	1.20
	212	7 to 1	16.5	328	11.0	23.0	0.90
	212	6 to 1	22.0	354	14.0	21.0	1.10
	350	6 to 1	14.5	488	3.0	16.0	1.00
A_4	212	8 to 1	11.5	321	6.0	31.0	2.05
	212	7 to 1	17.5	340	11.0	30.0	1.90
	212	6 to 1	22.5	342	14.0	30.0	1.90
	350	6 to 1	15.5	494	1.5	27.0	1.70
A_5	212	8 to 1	14.0	316	6.0	46.5	6.40
	212	7 to 1	20.0	340	11.0	47.0	7.40
	212	6 to 1	29.5	359	14.0	48.0	7.00
	350	6 to 1	18.0	508	4.5	52.5	6.70
A_6	212	8 to 1	15.0	320	6.0	56.0	11.00
	212	7 to 1	20.0	335	11.0	58.0	14.50
	212	7 to 1	21.0	331	11.0	57.0	18.00
	212	6 to 1	32.5	359	14.0	54.0	10.50
	350	6 to 1	18.5	518	5.0	52.0	6.80

TABLE 2—TETRAETHYL-LEAD ADDITIONS TO FUEL X TO GIVE KNOCK RATINGS EQUAL TO VARIOUS PERCENTAGES OF BENZENE IN THE SAME FUEL

Jacket Temperature, Deg. Fahr.	Compression Ratio	Throttle Opening, Deg.	Air Temperature, Deg. Fahr.	Humidity, Per Cent	Tetraethyl Lead, Cc. per Gal.
		30 Per Cent of Benzene			
212	10.00 to 1	7.0	70	48	1.10
	6.90 to 1	12.0	74	54	1.15
	6.50 to 1	23.0	66	61	1.40
	5.85 to 1	Full	68	42	1.30
275	10.00 to 1	7.0	68	38	0.90
	7.50 to 1	12.5	77	63	1.00
	7.00 to 1	12.0	..	..	1.10
	8.00 to 1	12.0	77	67	1.10
	6.50 to 1	17.5	66	53	1.20
	5.38 to 1	Full	78	58	1.20
350	10.00 to 1	7.0	70	48	0.60
	8.00 to 1	8.5	85	53	0.65
	6.50 to 1	14.0	70	48	1.00
	6.50 to 1	12.5	79	68	0.95
	4.80 to 1	Full	78	75	1.00
		40 Per Cent of Benzene			
212	10.00 to 1	10.0	62	50	2.15
	8.85 to 1	12.0	74	54	2.20
	6.50 to 1	27.0	66	61	2.90
	6.15 to 1	Full	68	42	3.40
275	10.00 to 1	8.0	77	54	1.90
	7.95 to 1	12.0	64	26	2.10
	7.50 to 1	14.0	77	63	2.35
	6.50 to 1	19.0	66	53	2.70
	5.56 to 1	Full	74	50	2.95
350	10.00 to 1	8.0	72	53	1.40
	8.00 to 1	9.5	85	57	1.50
	6.70 to 1	12.0	74	..	1.70
	6.50 to 1	14.0	79	68	1.70
	5.10 to 1	Full	78	75	2.50
		50 Per Cent of Benzene			
212	10.00 to 1	11.0	62	50	4.10
	9.10 to 1	12.0	72	55	5.00
	8.00 to 1	15.0	..	..	5.50
	6.50 to 1	41.0	66	61	6.40
	6.50 to 1	Full	70	45	6.90
275	10.00 to 1	9.0	77	54	3.20
	8.25 to 1	12.0	64	26	3.90
	7.50 to 1	15.0	77	63	4.90
	6.50 to 1	20.0	66	53	5.90
	5.80 to 1	Full	74	50	6.00
350	10.00 to 1	8.8	72	53	2.40
	8.00 to 1	10.0	68	38	2.60
	7.50 to 1	12.0	76	46	3.20
	6.50 to 1	15.0	79	55	4.10
	6.50 to 1	16.0	68	55	5.60
	5.30 to 1	Full	75	62	5.60
		60 Per Cent of Benzene			
212	10.00 to 1	13.0	69	40	9.70
	9.50 to 1	12.0	72	55	9.20
	8.00 to 1	19.0	79	53	11.40
	7.05 to 1	Full	70	45	14.30
275	10.00 to 1	10.0	70	44	6.90
	8.85 to 1	12.0	68	38	8.30
	8.00 to 1	16.0	79	71	11.60
	7.50 to 1	17.0	77	63	11.00
	6.50 to 1	24.0	70	48	11.80
	6.30 to 1	Full	74	50	12.40
350	10.00 to 1	9.0	67	38	4.80
	8.00 to 1	12.0	72	38	6.60
	7.90 to 1	12.0	..	..	6.60
	6.50 to 1	17.5	80	47	8.20
	6.50 to 1	17.5	79	55	9.10
	5.45 to 1	Full	75	62	10.10

Fuels A_2 to A_6 were rated against Fuel A_1 by adding tetraethyl lead or benzol to the latter. The term "benzol" is used in this paper to indicate commercial motor benzol, which is crude benzene. "Benzene" is used to designate chemically pure benzene. Compression ratios of 6, 7 and 8:1 were employed at 212 deg. fahr. jacket temperature and 6:1 at 350 deg. fahr. jacket temperature. The spark-advance was adjusted for each compression-ratio to the position of maximum power. Cylinder-head temperatures were recorded by a thermocouple.

Part 2—These data consist of determinations under a wide variety of conditions of the quantity of tetraethyl lead in a Mid-Continent straight-run gasoline to equal 30, 40, 50 and 60 per cent of chemically pure benzene in the same gasoline. In one case the compression ratio was kept constant at 6.5:1, and the fuel matches made at 212, 275 and 350 deg. fahr., the throttle being adjusted to keep the knock intensity constant. In another case the same experiments were carried out at 10:1 compression-ratio. In another case the throttle was kept wide open, and fuel matches made at 212, 275 and 350 deg. fahr., the compression ratio being adjusted to keep the knock intensity constant.

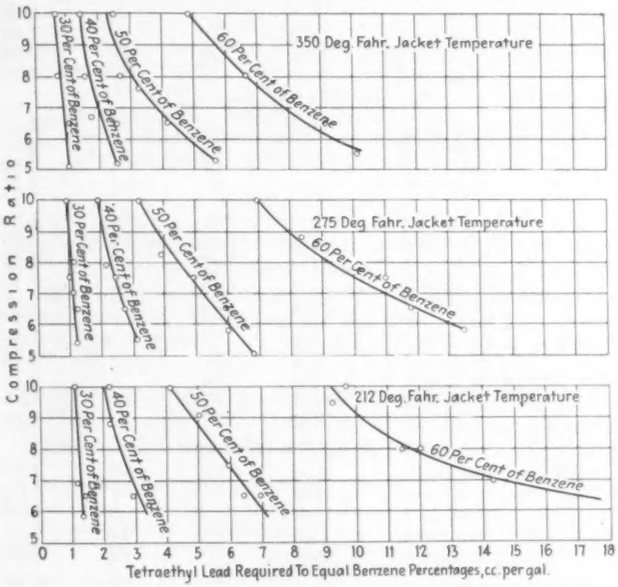

Compression Ratio
350 Deg. Fahr. Jacket Temperature
275 Deg. Fahr. Jacket Temperature
212 Deg. Fahr. Jacket Temperature
30 Per Cent of Benzene
40 Per Cent of Benzene
50 Per Cent of Benzene
60 Per Cent of Benzene
Tetraethyl Lead Required To Equal Benzene Percentages, cc. per gal.

FIG. 4—LEAD EQUIVALENTS OF DIFFERENT BENZENE PERCENTAGES PLOTTED AGAINST THE COMPRESSION RATIOS

These Results Are Shown for Temperatures of 212, 275 and 350 Deg. Fahr. and Benzene Percentages of 30, 40, 50 and 60. The Spark-Advance Was Fixed at 15 Deg.

In another case this technique was repeated except that the throttle was kept fixed at 12 deg. In still another case the compression-ratio was kept constant at each temperature but differing for the three temperatures, the adjustment of knock intensity for the different fuels being made by adjusting the throttle. The spark-advance was kept constant at 15 deg. Unfortunately, the cylinder-head equipped with thermocouple became inoperable, and the data in Part 2 were obtained with a new head that was not equipped with a thermocouple.

The experimental data are given in Tables 1 and 2 and are expressed graphically in the charts.

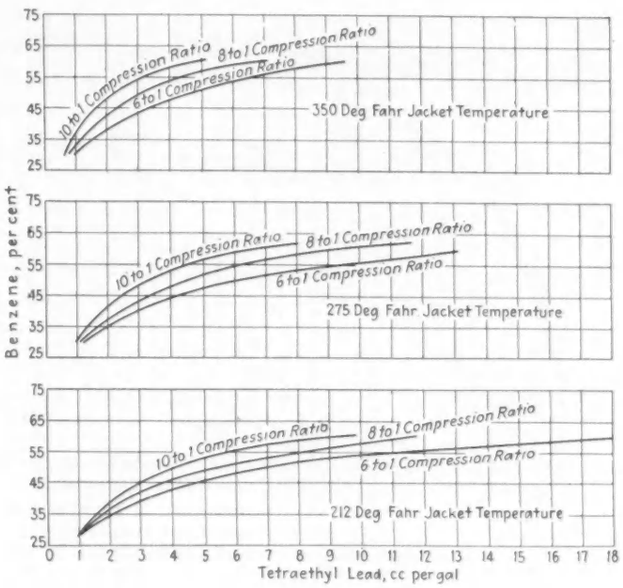

Benzene, per cent
10 to 1 Compression Ratio
8 to 1 Compression Ratio
6 to 1 Compression Ratio
350 Deg Fahr Jacket Temperature
275 Deg Fahr Jacket Temperature
212 Deg Fahr Jacket Temperature
Tetraethyl Lead, cc per gal

FIG. 5—RELATION BETWEEN TETRAETHYL LEAD AND BENZENE AT DIFFERENT COMPRESSION-RATIOS AND VARIOUS CYLINDER-HEAD TEMPERATURES

The Data of Fig. 4 Have Been Replotted as a Function of the Compression Ratio for Cylinder-Head Temperatures of 212, 275 and 350 Deg. Fahr. The Compression Ratios Chosen Were 6, 8 and 10 to 1. The Spark-Advance in This Case Was Also 15 Deg.

Treatment of Experimental Data

Inspection of the data in Table 1 indicated irregular and usually small variations with compression ratio at constant temperature. The cylinder-head temperatures at constant jacket-temperature varied, however, with the compression ratio, and the data were therefore plotted against cylinder-head temperature, the lead ratings being shown in Fig. 1 and the benzol ratings in Fig. 2. The experimental points lie surprisingly close to smooth curves, even including the points taken

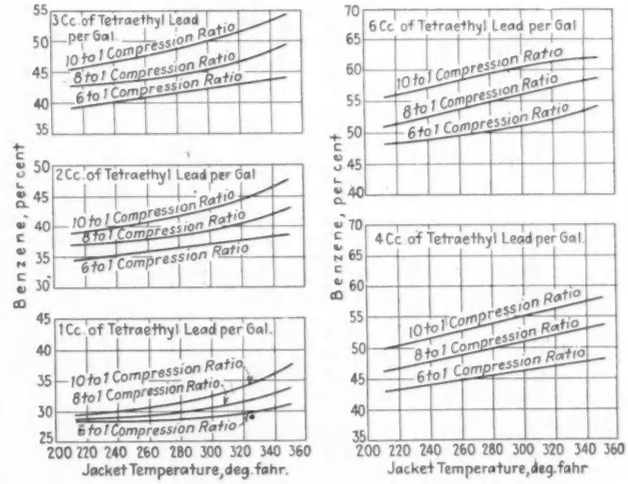

Benzene, percent
3 Cc. of Tetraethyl Lead per Gal.
2 Cc. of Tetraethyl Lead per Gal.
1 Cc. of Tetraethyl Lead per Gal.
6 Cc. of Tetraethyl Lead per Gal.
4 Cc. of Tetraethyl Lead per Gal.
10 to 1 Compression Ratio
8 to 1 Compression Ratio
6 to 1 Compression Ratio
Jacket Temperature, deg. fahr.

FIG. 6—TETRAETHYL-LEAD EQUIVALENTS OF DIFFERENT PERCENTAGES OF BENZENE PLOTTED AS A FUNCTION OF THE JACKET TEMPERATURE

These Curves Show This Relation for Compression Ratios of 6, 8 and 10 to 1 with a Fixed Spark-Advance of 15 Deg.

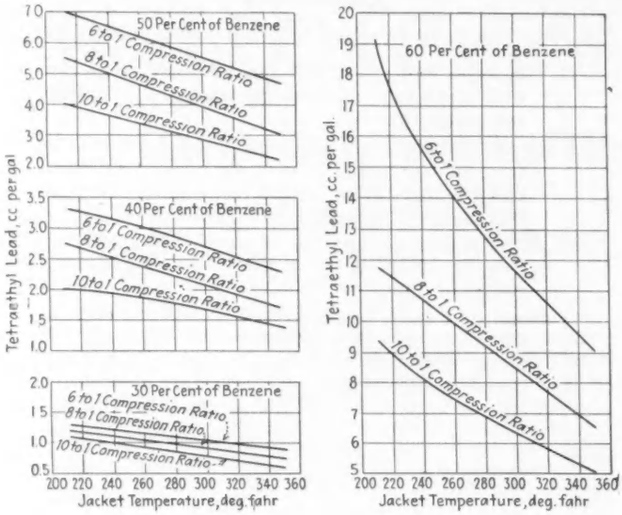

50 Per Cent of Benzene
6 to 1 Compression Ratio
8 to 1 Compression Ratio
10 to 1 Compression Ratio
40 Per Cent of Benzene
30 Per Cent of Benzene
60 Per Cent of Benzene
Tetraethyl Lead, cc per gal
Jacket Temperature, deg. fahr
200 220 240 260 280 300 320 340 360

FIG. 7—PERCENTAGES OF BENZENE WHICH ARE THE EQUIVALENTS OF DIFFERENT QUANTITIES OF TETRAETHYL LEAD PLOTTED AS A FUNCTION OF THE JACKET TEMPERATURE

The Relation Is Shown for Benzene Percentages of 30, 40, 50 and 60 and Compression Ratios of 6, 8 and 10 to 1. The Spark-Advance in This Case Was Also 15 Deg.

TABLE 3—TETRAETHYL-LEAD ADDITIONS TO FUEL *X* TO EQUAL VARIOUS PERCENTAGES OF BENZENE IN THE SAME FUEL

Jacket Temperature, Deg. Fahr.	Compression Ratio	Throttle Opening, Deg.	Atmospheric Temperature, Deg. Fahr.	Humidity, Per Cent	Spark-Advance, Deg.	Tetraethyl Lead, Cc. per Gal.
		30 Per Cent of Benzene				
350	8 to 1	9.5	70	56	12.5	1.05
	10 to 1	8.5	70	55	8.5	0.95
		40 Per Cent of Benzene				
350	6 to 1	16.0	75	61	16.5	1.90
	8 to 1	10.0	66	36	12.5	1.80
	10 to 1	9.0	71	48	12.5	1.70
		50 Per Cent of Benzene				
212	6 to 1	50.0	70	48	16.5	5.30
	8 to 1	18.0	70	48	12.5	5.30
	10 to 1	12.0	70	48	8.5	5.30
275	6 to 1	22.0	70	25	16.5	4.40
	8 to 1	13.0	70	25	12.5	3.95
	10 to 1	10.0	70	25	8.5	3.70
350	6 to 1	15.5	67	43	16.5	4.00
	8 to 1	11.0	67	43	12.5	3.10
	10 to 1	9.0	69	35	8.5	2.80
		60 Per Cent of Benzene				
350	8 to 1	12.5	70	55	12.5	6.90
	10 to 1	10.5	70	55	8.5	6.10

at 350 deg. fahr. jacket temperature, and the logical interpretation would seem to be that the ratings are affected only indirectly by the compression ratio and that the cylinder-head temperature determines the knock rating, whether this temperature be varied by varying the compression ratio or by varying the jacket temperature.

If the lead-benzol equivalents be read off from the smooth curves of Figs. 1 and 2, they can be plotted, for this particular gasoline, as a function of cylinder-head temperature. This is shown in Fig. 3 and illustrates the fact that at high cylinder-head temperatures lead becomes relatively more effective than benzol as an antiknock agent.

Inspection of the data in Part 2 showed that, contrary to the results of Part 1, a definite trend was observable in the lead-benzene equivalents at constant jacket-temperature but different compression-ratios. Individual data are occasionally out of line, but the trend is very definite. Since the throttle opening must always be changed for a given fuel when the compression ratio is changed, the data also show a trend with throttle opening, but considering compression ratio as the variable, rather than throttle opening, seems more logical.

The data were accordingly treated as follows: With compression ratios as ordinates, the lead equivalent of the different benzene percentages was plotted as abscissas at each jacket temperature and smooth curves were drawn through the points. (See Fig. 4). From these curves the quantities of lead equivalent to the different benzene percentages were plotted for compression ratios of 6, 8 and 10:1 respectively and for each jacket temperature. (See Fig. 5). Fig. 6 shows the quantities of lead necessary to equal 30, 40, 50 and 60 per cent of benzene as a function of jacket temperature at each compression ratio, and Fig. 7 shows the percentages of benzene necessary to equal different quantities of lead as a function of jacket temperature and at three compression ratios.

That the data show some irregularities is to be expected, as such engine conditions as carbon accumulation varied of necessity, and no control of atmospheric conditions was attempted. Furthermore, we cannot be certain that the knock intensity did not vary from time to time, particularly since such a wide range of conditions was studied. Undoubted variations that were present in these factors probably affected the individual results.

Comparison of Data in Parts 1 and 2

Reconciling the results of Parts 1 and 2 is at first difficult. In Part 1 no definite trend of the lead-benzol equivalents with compression ratio was observed, and in general the higher the compression ratio the cooler the cylinder-head temperature, which is readily accounted for by the smaller throttle-opening at the higher compressions. In Part 2 the higher the compression ratio the more effective the lead with reference to benzene, although presumably the cylinder-head temperatures were becoming lower as the compression was raised. The results, therefore, appear diametrically opposed to those shown in Fig. 3.

The differing experimental conditions of Parts 1 and 2 are apparently only four: different operators, different cylinder-heads, different gasolines and a difference in spark setting. In Part 1 the spark was always set for maximum power, while in Part 2 it was kept fixed at a 15-deg. advance.

The most probable cause of the difference in the results appeared to be the spark position, and accordingly experiments were undertaken to determine this point. Benzene blends with Fuel *X* were matched against tetraethyl lead at 6, 8 and 10:1 compression ratios at 212, 275 and 350 deg. fahr. jacket temperature. A redetermination was made of the spark position for maximum power at the compression ratios in question and the determinations carried out at these settings. Actual data were obtained at 212 and 275 deg., and these did not differ appreciably. Time was lacking to

determine the data at 350 deg. and the spark settings used were accordingly the same as at 212 and 275 deg. The results are given in Table 3. The data had been only partly completed at the time that this paper was written.

The data at 212 deg. fahr. show identical results for the three compression-ratios, which is in general agreement with the data in Part 1, indicating that the effect of varying the compression ratio is small, at least when the spark is set for maximum power. The data at 275 and 350 deg. fahr. indicate a slight trend with varying compression-ratio in the same direction as that shown in Part 2, but the trend is small in comparison. These data tend to explain the differences that were found to exist between the results obtained in Part 1 and in Part 2.

Conclusions

Taking the data as a whole, they indicate that

(1) The relative antiknock value of fuels is in general definitely affected by changes in jacket temperature.

(2) If the spark-advance is fixed, marked differences may be expected in results obtained at different compression-ratios, when comparing benzene blends with tetraethyl-lead blends.

(3) If the spark-advance is adjusted for maximum power, the effect of varying the compression ratio is minimized.

(4) Some indication is given that all results may be functions of the cylinder-head temperature alone, although the data are not sufficiently complete to be conclusive.

Wind-Tunnel Tests and Body Design

(*Concluded from p. 32*)

fers less air resistance. To shape front fenders or the car to make it look as though it could fly must never go beyond looks, however, for the car must always hug the ground to give good steering control. We may even question whether it should look as if it could fly, for a well established precept in esthetics is that design should conform to usage, and, although flying is the greatest means of speed, it is not the only one.

We might change the concepts of beauty in regard to the automobile and try to portray a fast but sturdy and safe conveyance instead of a light and fleet one. For example, Captain Campbell's Blue Bird has no flying characteristics; the designer wanted it to stay on the ground, and it looks sturdy and massive. Yet, on account of its lines or its length and lowness, it certainly gives an impression of great speed capacity. To change our taste in regard to anything is not impossible. Consider that within a few years our National preference in the female figure has changed from the plump, curved type to the slim and straight type that most men admire today, which shows that even our most fundamental taste can be changed in a short time.

Ventilation also an Aerodynamic Problem

The problem of ventilation in our automobile bodies needs attention, and we can enlist the aid of the aerodynamics expert in this also. That any automobile or body manufacturer has ever attacked this problem in a scientific way is doubtful, for ventilation is no better today than it was some years ago. Perhaps it is not as good in many cases, for, notwithstanding all the faults of the two-piece windshield, it had some ventilating merits. We place now too much blind confidence in cowl ventilators. Much time has been spent on them by engineering departments, not with the aim of increasing their ventilating efficiency but to prevent them from leaking and rattling, and mainly to avoid the paying of patent royalties. Possibly no manufacturer has ever conducted a test to find out how much air passes through them. Some day someone will be surprised to find that he is not getting any, for it should not be taken for granted that every time we make a hole in the body we shall get air through it when the car is in motion; there may be an air pocket at that place. We should experiment with the position of the opening, its correct size and the shape of the lid and other parts, and use those areas of suction that, unfortunately, exist at the rear and other parts of the body. We shall find out in the future that it will be unnecessary to open a windshield, but to accomplish this we must enlist the aid of the expert and his equipment.

Aerodynamics may offer many advantages and some disadvantages as regards esthetics and originality in design. The main disadvantage is the fact that, when all of those engaged in the same undertaking try to reach the same ideal, the individuality will be less the closer we approach the ideal. However, as in this case the ideal is virtually impossible of attainment, we shall always be far enough from it to hold the little individuality we have today.

The body designer may think that aerodynamics will also help the chassis designer by increasing the speed of the car but that his difficulties will be increased through the restrictions of his originality by mathematical rules and physical laws. This may be true if judged by some esthetes, but others will be of a different opinion. Two well-known authorities on this subject disagree in their theories but agree that ornamentation and radical departures from the customary shape of a useful object like the automobile should be made with at least the excuse of some utilitarian purpose; that is, beauty disguised in usefulness is more attractive than beauty by itself. This is a psychological fact that all designers engaged in industrial arts should remember. Most of us are still prosaic enough not to enjoy beauty unless it brings us some material gain. For that reason and with such a good and appealing purpose or excuse as that of decreasing the air resistance of our automobiles, designers have, in aerodynamics, a new source of inspiration and a new motive for the models to be made.

Effect of Oil Consumption and Temperature on Octane-Number Ratings

Annual Meeting Paper

By H. R. Stacey[1]

STATING that variation in knock-testing results with a relatively high oil-consumption is partly due to the oil itself, the series of tests conducted at the laboratory of the Standard Oil Development Co. is described. This is supplemented by tables giving the average results obtained in several tests in which the operating conditions were very carefully controlled.

Conclusions drawn by the author are that the error due to different rates of oil consumption and variation of oil temperature may be as great as one octane number and is not affected by the kind of oil used. Recommendations that the oil consumption be kept at the minimum for safety and good operation and that the oil temperature be kept constant at as low a value as is consistent with good lubrication are made.

WHEN the oil consumption is relatively high, the experience of many users of knock-testing engines has been that the results obtained are subject to variation. This condition is not completely changed by cleaning the carbon from the combustion space in cases where the oil consumption is such as to give excessive carbon-deposits, and undoubtedly part of this variation is caused by the oil itself. Moss and King[2] have shown that the partial admixture of the lubricating oil with the incoming charge has a deleterious action on the antiknock value of fuels. The differences obtained with oils and fuels by reference to secondary standards based on mixtures of iso-octane and normal heptane are evaluated in this paper.

Test Apparatus and Conditions

The apparatus used was an Ethyl Gasoline Corp. water-cooled engine fitted with a mercroid temperature-control on the intake air and with heating and cooling coils in the oil sump. The temperatures of the intake air and of the oil in the sump were measured by thermocouples. All tests were made at the air-fuel ratio for maximum knock and at a knock intensity for reliable readings on the bouncing-pin.

The following were kept constant during the tests: speed, 600 r.p.m., by a synchronous motor attached to the crankshaft; intake-air temperature, 85 deg. fahr.; spark-advance, 22 deg. before top center; and water-jacket temperature, 212 deg. fahr.

Two oils having a Saybolt viscosity of 62 sec. at 210 deg. fahr. were chosen, one made from Pennsylvania and the other from Coastal crude. These oils were selected because of their wide general use and their different natural properties.

Two base gasolines were used,

(1) Straight-run California of good antiknock value
(2) Straight-run Burbank of poor antiknock value

From the Burbank, two fuels were made to equal the octane number of the California by the addition of tetraethyl lead and a benzol having an end-point of 212 deg. fahr. These fuels were matched in octane number, using Pennsylvania oil in the crankcase with its temperature held constant at 110 deg. fahr. The oil consumption of the engine was approximately ½ per cent of the fuel consumption, being kept low by a close-fitting piston and two oil-rings. The Burbank then required 1.8 cc. of tetraethyl lead or 34 per cent of benzol to equal the California gasoline. Changing the oil in the crankcase from Pennsylvania to Coastal made no difference in the results, showing that under conditions of low oil-consumption no relative change was found in the octane number. This procedure allowed the investigation of three different fuels of equal octane number under standard test-conditions; namely, (*A*) straight-run California, (*B*) straight-run Burbank plus 1.8 cc. of tetraethyl lead per gal., and (*C*) 66 per cent of straight-run Burbank plus 34 per cent of benzol.

TABLE 1—EFFECT OF ADDING PENNSYLVANIA AND COASTAL OILS TO THE TEST FUELS

Fuel	Oil in Fuel, Per Cent	Octane Numbers — Pennsylvania Oil — 110 Deg. Fahr.	Pennsylvania Oil — 185 Deg. Fahr.	Coastal Oil — 110 Deg. Fahr.	Coastal Oil — 185 Deg. Fahr.
A	0	67.6	67.6	67.6	67.5
B	0	67.6	67.6	67.6	67.4
C	0	67.6	67.3	67.6	66.9
A	4	66.3	66.3	66.9	66.5
B	4	65.9	66.5	66.5	65.9
C	4	65.6	66.3	66.9	66.3
A	8	65.3	63.2	66.5	64.4
B	8	64.1	63.2	65.9	64.1
C	8	64.7	62.9	64.7	64.1

Causes of Variations in Octane Numbers

We assumed that variations in octane numbers with different rates of oil consumption would be due to two causes,

(1) Partial admixture with the incoming charge by leakage past the piston
(2) Differences in cooling of the piston due to different rates of heat transfer between the piston and the cylinder-wall

The relative contributions of (1) and (2) are impossible to obtain, but the direction of the effect of (1) was obtained by dissolving the oils in the fuels and of

[1] M.S.A.E.—Research engineer, Standard Oil Development Co., Elizabeth, N. J.

[2] See *Engineering*, July 11, 1930, p. 31, and July 25, 1930, p. 99.

(2) by changing the temperature of the oil in the sump. This latter gave the effect of change of oil temperature during actual testing. The effect of change in oil consumption was found by increasing the volume of oil in the sump and fitting a loose piston.

Table 1 shows the effect of adding Pennsylvania and Coastal oils to the three fuels, *A*, *B* and *C*, using in each case the same oil in the crankcase. The crankcase-oil consumption was ½ per cent of the fuel consumption.

The Pennsylvania and Coastal oils added to the fuels lowered the octane number in all cases at both oil-temperatures and had slightly more effect on Fuels *B* and *C*. Apparently in the case of the 8 per cent of oil in the fuels the Pennsylvania oil had slightly more deleterious action than the Coastal oil. A very small part of the differences shown under the two oil-temperatures might be ascribed to changes in the engine oil-consumption due to changes in viscosity of the crankcase oil at the two test-temperatures.

The oil consumption was increased to 2 per cent of the fuel consumption by fitting a loose piston and increasing the volume of oil in the crankcase. Pennsylvania oil was used and the temperature held at 110 deg. fahr. Table 2 shows the octane numbers obtained on the three fuels with different oil-consumptions.

TABLE 2—CHANGE IN OCTANE NUMBER WITH DIFFERENT OIL-CONSUMPTIONS

Fuels	Oil Consumption in Terms of Fuel Consumption, Per Cent	Condition of Exhaust	Octane Number
A	½	Clear	67.6
B	½	Clear	67.6
C	½	Clear	67.6
A	2	Smoky	66.9
B	2	Smoky	66.9
C	2	Smoky	66.9

The engine was noticeably erratic with high oil-consumption. The combustion space was cleaned before all check runs, but this failed to improve engine irregularities. The increase in oil consumption decreased the octane number of all three fuels by 0.7.

Probably a wider variation between different fuels in these tests would have been found if the fuels had contained larger quantities of tetraethyl lead or benzol. However, the results are based on fair averages of ethyl fluid or benzol marketed in gasolines at present and should be representative of the variations that might be expected in the general run of testing.

Effect of Higher Oil-Temperatures on Secondary Reference-Standards

To estimate truly the effect of the higher temperature of the oil on the different fuels, a knowledge of the effect of the higher temperature on the secondary reference-standards is necessary. These consisted of

(1) Straight-run California
(2) 17 per cent of straight-run Colombia plus 83 per cent of straight-run Oklahoma City

These two gasolines with varying quantities of tetraethyl lead had previously been rated in terms of octane numbers under standard test-conditions and 110-deg. fahr. oil-temperature.

The effect of oil-temperature changes on these secondary standards and on two fuels containing larger quantities of tetraethyl lead or benzol than were used in previous tests is shown in Table 3. These fuels were rated directly in terms of pure iso-octane and normal heptane. The oil consumption of the engine for this test was ½ per cent of the fuel consumption.

TABLE 3—EFFECT OF OIL TEMPERATURE ON THE OCTANE NUMBER

Fuels	Octane Number: Oil Temperature, 110 Deg. Fahr.	Octane Number: Oil Temperature, 185 Deg. Fahr.
Secondary Reference-Standard 1 plus 1.9 Cc. of Tetraethyl Lead	67.6	67.6
Secondary Reference-Standard 2	67.6	67.5
50 Per Cent of Benzol plus 50 Per Cent of Burbank	77.5	77.0
Straight-run Burbank plus 4.8 Cc. of Tetraethyl Lead	77.2	77.1

The change in oil temperature affected the relative ratings of the benzol blend 0.5 of an octane number. The higher oil-temperatures increased the degree of knock intensity for all three fuels and this was rectified by a slight change in throttle opening. The secondary reference-standards gave practically the same results as the actual octane-heptane mixtures.

As a matter of interest, the California secondary-standard plus various additions of tetraethyl lead, when tested directly against octane-heptane mixtures at 212 and 300 deg. fahr. cooling-medium temperatures, have the same octane number at both temperatures. The Colombia-Oklahoma City mixture with small quantities of tetraethyl lead differed in octane number at the two temperatures but these results gradually came together with higher concentrations of tetraethyl lead.

That the effect of oil consumption and oil temperature on the ratings of different fuels might be considerably greater if other engine-conditions were used, such as higher cylinder cooling-medium temperature and higher induction-temperatures, is, of course, very conceivable. Some of the differences shown by these tests are within the range of experimental error for rountine tests, ±1.0 octane number, but the figures shown are the averages of several tests in which the operating conditions were very carefully controlled.

Conclusions

The following conclusions are drawn:

(1) Errors due to different rates of oil consumption of test engines are approximately one octane number in testing commercial fuels.
(2) The error due to variation of oil temperature may be as much as one octane number.
(3) The two different mineral-oils used made no difference to conclusions (1) and (2).

The usefulness of a universal secondary-standard based on the primary-standard mixtures of iso-octane and normal heptane is also shown if concordant results are to be obtained. The universal use of such a secondary standard would make many engine-variations have less significance in relative ratings.

All knock-testing engines should be designed and run with the oil consumption at the minimum for safety and good operation. This improves the degree of accuracy of the results, decreases the carbon formed in the combustion space and results in steadier running of the engine. The oil temperature should be maintained constant and kept as low as possible consistent with good lubrication.

Recent Developments in Poppet Valves

By A. T. Colwell[1]

Semi-Annual Meeting Paper

AFTER stating that increased speed, mean effective pressure and piston displacement of engines have made valve conditions more difficult during the last few years, the author recalls the path which development has followed by a brief list of materials and methods of cooling.

Where the stem joins the head is the hottest part of the valve. A shield for this point is shown, also a shroud to protect the end of the valve-stem guide. Cooling the valve increases its life. Salt and sodium cooling are compared, and methods of sealing the coolant in place are described.

The construction and behavior of copper-cooled valves are illustrated and recounted, and a one-piece hollow-head valve is described. Reasons for valve-seat inserts are given.

EXHAUST valves of both aircraft and automobile engines are today subject to far more severe conditions than they were a few years ago. On automobiles, this is due to increases of approximately 21 per cent in engine speed, 19 per cent in brake mean effective pressure and 8 per cent in piston displacement during the last few years. Power increase in aircraft engines has likewise caused more severe valve-operating conditions. Higher compression alone is favorable to valve temperature; however, when this is coupled with higher speeds and improved volumetric efficiency, more heat passes the exhaust valve in a given time.

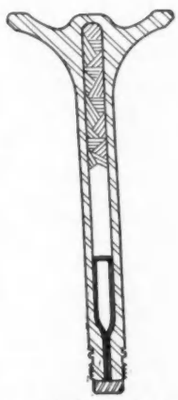


Fig. 1—Valve Sealed by Swaging, with Thimble To Keep Spring Cool

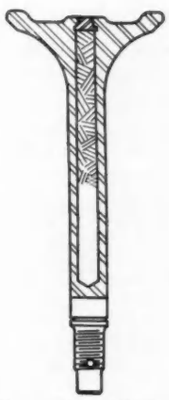


Fig. 2 — Hollow Stem Closed by Plug in Head

SODIUM-COOLED VALVES

The hottest part of an exhaust valve is the radius portion under the head. This is due to the heat of the impinging exhaust flame and its distance from the cooling of the block seat and the guide. Valves often fail at this point because of the lowered strength at heat and the tremendous bending moment which may be caused when the valve strikes one side of the block seat and then slaps into place. This action is permitted by too large guide-clearance or worn guides.

The stress in the outer fiber of a heavy valve may be over 20,000 lb. per sq. in.; it is therefore necessary to cool many valves in some way to maintain the strength of the steel. Cooling valves increases their life greatly and retards detonation. Ethyl gasoline allows higher compression-ratios, and cooled valves are an aid with these higher ratios in airplane engines, particularly when supercharging is used.

Valve materials and types have progressed through a long series of developments, briefly, as follows: Cast-iron valve with steel stem, cast-iron valve reinforced with steel wire, the one-piece steel valve, the same valve with a puddled seat of cast iron, the nickel-head valve, the tungsten valve, the EWP (Electric Welding Products) alloy of low chromium-nickel, cobalt-chrome, Silcrome, CNS (chromium-nickel-silicon), salt and sodium cooling and copper cooling.

Valve-development work is proceeding along two lines. One is to find better steel for exhaust valves, the other, to improve the operation of present steels in various ways. Cooling by salt is an effective method, the salt used being a eutectic mixture of two-thirds potassium nitrate and one-third lithium nitrate. Sodium now is replacing salt as a coolant because of its physical properties, which are given in Table 1. In addition, the vapor pressure of sodium is far below that of salt. This allows a valve to be heat-treated after being filled with sodium, whereas this procedure is not satisfactory with salt, because of the high pressure developed.

Sodium is more dangerous than salt to handle, as it reacts violently with water and the reaction is intensified to explosion if pressure is applied. The sodium

TABLE 1—PHYSICAL PROPERTIES OF SODIUM AND OF EUTECTIC MIXTURE OF POTASSIUM AND LITHIUM NITRATES

	Sodium	Eutectic
Melting Point, deg. fahr.	207.5	265.0
Boiling Point, deg. fahr.[a]	1,616	...
Surface Tension at Fusion Temperature, dynes per cm.	258	100[b]
Heat Equivalent of Fusion, cal. per gm.	31.7	55[b]
Specific Gravity	0.97	2.2

[a] Potassium nitrate decomposes at 750 deg. fahr.
[b] Approximate.

[1] M.S.A.E.—Chief engineer, Thompson Products, Inc., Cleveland.

must be kept under kerosene until ready for use. Before filling, valves are preheated to 700 deg. fahr. to drive out all moisture and also to create a partial vacuum after the valve is closed and has become cool. Solid sodium is placed in the stem, and the valve is immediately sealed.

Considerable progress has been made in the process of sodium filling. In some cases it is desirable to block the sodium well up the stem to prevent heat from reaching the spring. The method of doing this with a capsule is illustrated in Fig. 1. A swaging operation seals the sodium, and the welded tip doubly seals.

Fig. 2 shows a method of inserting a cold plug in the head and then pressing the valve nubbin in around it. This method seals the sodium effectively, but any sealing operation in the head or hot portion of the valve is not considered to be the best practice. A plug is sometimes screwed and welded into the head of the valve. An objection to this method is that the welding heat expands the entrapped air, causing blow-holes in the weld.

Fig. 3 shows a satisfactory method of sealing the sodium without swaging. A plug is pressed against a shoulder in the stem; behind this two copper gaskets are placed and a threaded plug forced against them with considerable pressure.

Hollow Heads and Shrouds

In Fig. 4 is a hollow-head one-piece valve. The process by which it was made holds considerable promise. No doubt cooled hollow-head valves will be widely used in the future. Raising a nubbin in the center of the valve and bringing sodium up into the head aids considerably in cooling, and this effect will be greatly increased in a hollow sodium-cooled head.

TABLE 2—THERMAL CONDUCTIVITIES OF VALVE MATERIALS

	B.t.u. per Hr. per Sq. Ft. per In. per Deg. Fahr.	Gm-Cal. per Sec. per Cc. per Deg. Cent.
No. 1 Silcrome	142	0.049
No. 2 Silcrome	174	0.060
CNS	128	0.044
Cobalt-Chrome Steel	183	0.063
No. 1025 Steel	390	0.134
Copper	2,640	0.908
Sodium (Liquid)	638	0.220
Mercury	55	0.019
Aluminum	1,450–2,900	0.50–1.00

TABLE 3—MISALIGNMENT BETWEEN SEAT AND STEM OF VALVE DURING 50-HR. TEST, MEASURED IN RUNOUT AT VALVE SEAT, IN.

Valve No.	At Start	At Finish
1	0.0020	0.0001
2	0.0010	0.0009
3	0.0008	0.0016
4	0.0001	0.0007
5	0.0005	0.0007
6	0.0013	0.0020

Guide clearance is important with cooled valves. It must be greater than with an uncooled stem; but too much clearance will cause heat to be held in the stem and result in expansion and loss of tappet clearance, particularly in L-head engines. A film of oil in the guide aids heat transfer.

Fig. 5 shows a valve having a Nicrome shield or shroud spun into the under side of the head. The lower end is free to move along the stem with expansion. The dead-air space between the valve and the shield acts as an insulator, and the shield prevents the exhaust flame from impinging on the stem. This construction is expensive, but it has merit in some cases.

A shroud over the valve guide, as used in Diesel engines to prevent the valve from sticking at the top of the guide, is shown in Fig. 6. The shield is spot-welded and rolled into a groove in the valve-stem. This device is very useful in some engines.

Copper Filling Aids Valve Cooling

Copper-cooled valves, such as those shown in Fig. 7, are the latest development. The copper is forged into the stem, and the type of steel used determines whether or not there is a bond between the steel and the copper; an absolute bond is shown in Fig. 8. In cases where there is no bond, the fit is so tight that excellent heat conductivity is obtained. The thermal conductivities of copper, sodium, and several valve steels are listed in Table 2. Alloying steel reduces its heat conductivity seriously; copper is more than 20 times as good in this respect as CNS, according to experimental determina-

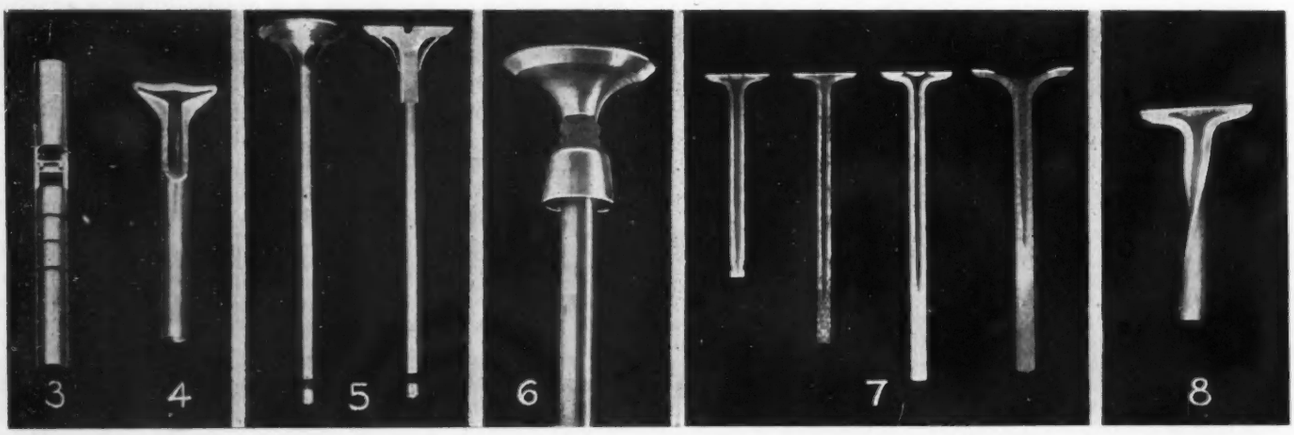


FIG. 3—HOLLOW STEM CLOSED BY SCREWED PLUG AND GASKETS

FIG. 4—ONE-PIECE HOLLOW VALVE

FIG. 5—VALVE HAVING SHIELD WHERE THE STEM JOINS THE HEAD

FIG. 6—VALVE-STEM PROVIDED WITH SHROUD AT TOP OF GUIDE

FIG. 7—VALVES COOLED BY COPPER INSERTS

FIG. 8—COPPER-INSERT VALVE TWISTED TO SHOW BOND BETWEEN METALS

tion with the apparatus shown in Fig. 9. The conductivity of aluminum increases as the temperature increases, but that of copper holds constant, being much the better of the two at low temperatures. Fig. 10 shows the theoretical increase in conductivity of a valve with copper insert over that of a solid steel stem. The conductivity by test is two-thirds the theoretical.

Running tests show that the copper-cooled valve runs at considerably lower temperature than a solid valve. The section of copper in the head can be varied and the cooling effect of the valve is controlled by this section. The temperature of the stem is far more uniform with the copper inlay, the heat being distributed over the entire section. The guide temperature is higher, but valve-stems fitted with conventional clearance have given no trouble in the smaller sizes.

Copper-cooled valves are much quieter in operation

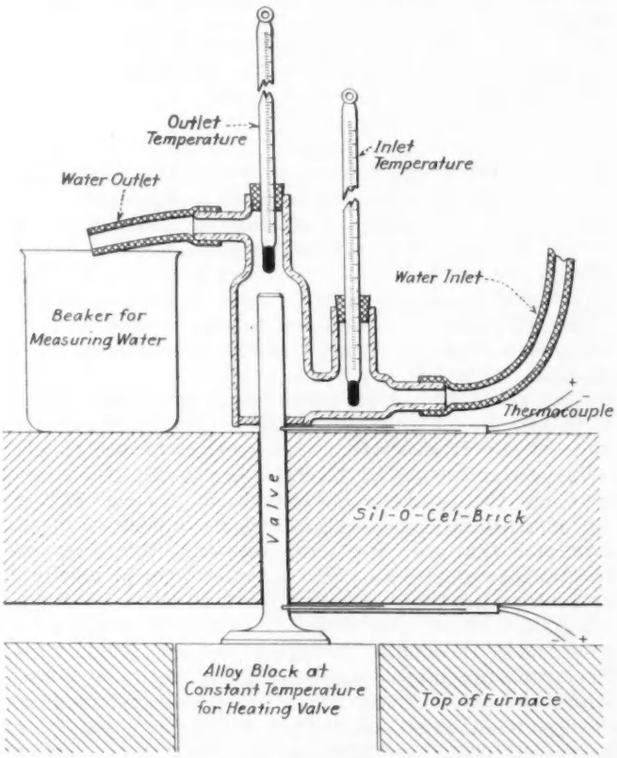


FIG. 9—TEST SET-UP TO MEASURE HEAT FLOW THROUGH VALVE-STEM

than solid valves, as they do not ring when struck. The results of a dynamometer test show that these valves maintain the alignment of head and stem remarkably well, as recorded in Table 3. This fact is important, as valves which seat properly will run much longer than valves that are unseated, however slightly.

A valve-stem composed of copper for 40 per cent of its diameter will actually transmit three times as much heat as a solid steel stem. The neck temperature has not exceeded 1325 deg. fahr. under the most severe conditions with copper cooling, while solid-stem valves in the same engine run at 1450 deg. The top of the valve-stem guide on an air-cooled engine ran 140 deg. hotter than the bottom of the guide, which was at cylinder-head temperature. In a water-cooled engine, the top of the guide ran at 420 deg. fahr.; which was also the tem-

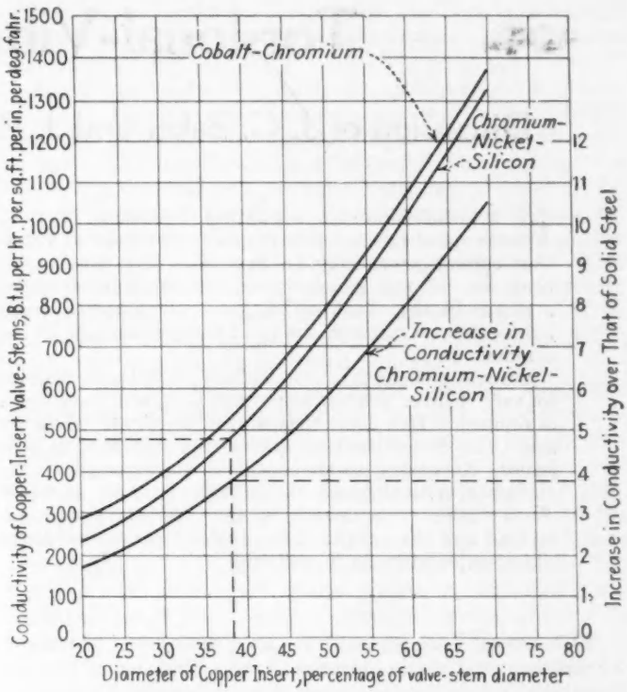

Cobalt-Chromium
Chromium-Nickel-Silicon
Increase in Conductivity Chromium-Nickel-Silicon
Conductivity of Copper-Insert Valve-Stems, B.t.u. per hr. per sq. ft. per in. per deg. fahr.
Increase in Conductivity over That of Solid Steel
Diameter of Copper Insert, percentage of valve-stem diameter
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500
0 1 2 3 4 5 6 7 8 9 10 11 12
20 25 30 35 40 45 50 55 60 65 70 75 80

FIG. 10—CONDUCTIVITY CURVES FOR STEEL AND COPPER-INSERT VALVE-STEMS

perature at the seat in the cylinder-block. The bottom of the guide was at 190 deg. Considerably more heat was dissipated through the guide than with a steel stem.

The insert type of valve provides a practical and comparatively inexpensive method of making a hollow-head valve, by using aluminum as the insert and melting it out after forging.

Preventing Pick-up on Valve Seats

One other subject at present very important to truck and motorcoach-engine manufacturers is that of "pick-up," or "warts," on valve-seats. Small file-hard spots appear on the seat of the valve and wear the block seat down very rapidly. The exact cause of this pick-up is not known, but I believe that it is essentially a heat condition. At high temperatures the material of the valve has an affinity for the material of the block. The very outer layer of block-seat material is probably at a high heat, approximating exhaust temperature. This thin outer layer causes the trouble, the valve gradually working down into the block through successive layers like this. The pick-up also unseats the valve, causing valve burning and drawing of the block, which is quickly followed by block pounding.

FIG. 11—PICK-UP OR WARTS ON VALVE-SEAT

There are several remedies for this condition,

(*Concl. on p.* 66)

Torsional-Vibration Dampers

Discussion of J. G. Baker and J. P. Den Hartog Annual Meeting Paper[1]

IN internal-combustion engines operating over a wide speed-range, critical speeds of torsional vibration cannot practically be avoided. The ensuing vibrations, if not checked, set up high alternating stresses in the shaft which have in numerous cases led to fatigue failures, many of these occurring in the crankshaft.

Several devices that successfully limit these stresses to safe values during any critical speed have been developed. The fundamentals of torsional vibration and these stress-limiting devices are discussed in this paper. According to the authors, the stresses set up during a critical speed can be calculated in advance. Tests made on a model in the laboratory are described and the results thus obtained prove the methods of calculation to be reliable.

The discussion included written contributions that were read at the meeting as well as remarks from the floor. Points brought out were the better performance of the dynamic type as compared with that developed by Lanchester, that the principle of operation of the friction and reaction types is fundamentally different, the frequency of torsional vibration is constant for a given crankshaft regardless of the speed at which critical vibrations occur, the exciting torque is the vectorial sum of the amplitudes of the exciting mechanism and the damper end of the shaft, and the desirability of using a built-up rate in the flexible member of the damper so that the rigidity in the lower harmonics is insufficient to add the damper moment of inertia directly to the crankshaft as in the high-friction type.

THOMAS C. VAN DEGRIFT[2]:—This discussion gives our experience with the dynamic-type vibration-absorber. Torsional vibration in a motor-car is very objectionable if driving in the speed range where violent torsional vibrations are occurring becomes necessary. Two factors that make the vibration objectionable are the lateral deflection of the main bearings, referred to by the authors, which is accompanied by a rattling of the timing gears, pistons and in fact anything connected to the crankshaft, and the bending involved in the torsion of the crankshaft, which acts to enlarge the main bearings by making them bell-mouthed. For automobile practice the range of permissible torsional-vibration amplitude varies considerably, depending upon the type of engine and its mounting on the chassis.

The research laboratory with which I am connected has made an investigation of the effectiveness of various types of damper on a model similar to the one used by the authors, and theoretical and engine tests were also made. The results of the mathematical analysis, the model and engine tests check one another with very good accord. Both the Lanchester and the dynamic types were investigated. The latter are of two distinct types: (*a*) without damping, which is used only on constant-speed engines where the torsional period is at the running speed, and (*b*) with damping, which is used on variable-speed engines. The latter requires a definite amount of damping and is effective as a torsional-vibration damper throughout the speed range of a variable-speed engine.

A comparison of the Lanchester and dynamic types shows that the latter gives better performance, that is, lower shaft-amplitudes for the same size damper, and uses much less damping. In practice, the inertia member is smaller for this type than the Lanchester to reduce the shaft amplitude to a given value. This bears out the authors' statement of what might seem possible with this type. Summing up these advantages, we have better performance, less weight and less friction. The damped dynamic type of vibration absorber is simpler to adjust. It enables the damping to be held constant throughout the speed range of the engine without interfering to a great extent with the effectiveness of the damper.

The trend in the motor-car field is toward engines with smaller exciting forces to produce torsional vibration of the crankshaft. The trend from six to eight cylinders and a higher number has made the fitting of dampers to motor-car engines much easier. The six-cylinder in-line engine is particularly difficult to fit with a damper that will effectively cope with the third-order inertia-torque period. The inertia torques are much smaller in the types of engine having the higher number of cylinders. On the other hand, the standard for smoothness is constantly rising so that, while a particular design might not need a damper from a high-stress standpoint, one might be necessary from the standpoint of quiet operation.

Friction and Reaction-Type Dampers

C. E. SUMMERS[3]:—The torsional-vibration problem is older than the automotive industry. It became acute in the first steamships employing a screw propeller driven by a multiple-cylinder steam-engine. In this connection it was exhaustively analyzed by Hermann Frahm in 1899. The problem was met again in the synchronous electric motor. Fluctuations in the frequency of the alternating current reacting on the elastic field of the motor caused critical vibrations in the armature-shaft assembly. Two dampers were developed by Alexander Churchward to control this torsional vibration. Both devices employed a flywheel mounted on the armature shaft but one was frictionally engaged and the other connected through springs. Both were successful in damping the vibrations of synchronous motors and both principles have been adapted to devices to damp torsional vibration of internal-combustion-engine crankshafts.

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[1] This paper was published in the February, 1931, issue of the S.A.E. JOURNAL, p. 184. The authors are research engineers with the Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa. For the convenience of the reader the abstract that preceded the paper when it was published is reprinted and is supplemented by a brief summary of the discussion.

[2] M.S.A.E.—Head of special problems section, General Motors Corp. Research Laboratories, Detroit.

[3] M.S.A.E.—Research engineer, Oakland Motor Car Co., Pontiac, Mich.

A fundamental difference in the principle of operation of these two dampers exists. In the case of friction dampers the ideal from a functional standpoint consists of a very heavy inertia-disc frictionally connected to the crankshaft. Slippage between the disc and the crankshaft dissipates the energy of vibration through friction. The dissipation of energy and the damping effect in a device of this character are directly proportional to the resistance to and the arc of slippage between the crankshaft and the disc. No damping occurs until the force of vibration results in actual slippage. The chief problem, therefore, in a design of this kind is to secure sufficient inertia and to obtain slippage at the lowest-energy periods and yet have sufficient vibration damping force at the highest-energy periods.

In the inertia or reaction type the problem is less simple. A design on this principle controls vibration through active opposition to the motion of the shaft. Its polar moment of inertia for application to a given shaft-assembly is very definite and is much less than that required in friction dampers. The rate of the springs and the polar moment of inertia of the mass are selected so as to give the damper a frequency that has a definite relation to the natural frequency of the crankshaft. Contrary to the case with friction dampers, the mass of the reaction damper moves more than does the crankshaft, in fact, several times more, and in a phase relation such that the spring tension connecting the damper with the shaft is always opposing the motion of the shaft. Therefore a small motion of the shaft excites the damper to an active opposition that tends to hold the shaft against motion. Since the damper controls the motion of the shaft itself, it thereby reduces the exciting cause of motion in the damper to a very small value. The friction in the damper itself, which is unavoidable with practical construction, is sufficient to cause the damper to subside as soon as the critical speed of the crankshaft has passed. This device therefore controls the two or three periods that may be found in crankshafts.

A significant fact is that the frequency of torsional vibration is constant for a given crankshaft regardless of the speed at which the critical vibrations occur. This fact is the fundamental basis of operation of the tuned reaction-damper. Assuming a six-cylinder-engine crankshaft-assembly having a natural frequency of 180 cycles per sec., we should expect a fundamental period at 3600 r.p.m. in which the crankshaft would vibrate 3 cycles per revolution, or in direct phase with the turning effort and inertia impulses. We should expect another critical period at 1800 r.p.m. in which the crankshaft would vibrate torsionally 6 complete cycles per revolution of the engine, and another critical period at 1200 r.p.m. in which we would have 12 complete cycles per revolution of the engine. Naturally, the force and amplitude of vibration become smaller as the number of swings per exciting impulse is increased, but the frequency does not change.

J. G. BAKER:—The effect of damping in the dynamic-vibration absorber should be emphasized. The curve in Fig. 5 marked, With Absorber, and the remarks relating thereto apply to a dynamic-vibration absorber with practically no damping between the absorber and the shaft, which is the best condition for a constant-speed engine. If appreciable damping is present, the situation is very different.

Referring again to this curve, suppose that we gradually add damping which is proportional to the relative velocity between the end of the crankshaft and the damper. As this damping is increased, the peaks of the curve are lowered and the valleys are raised until a condition is reached in which the maximum amplitude attained throughout the whole curve is the minimum, the optimum condition for a variable-speed engine[4]. With still further increase in damping, the curve becomes single-peaked until finally the damping becomes so large that the absorber is in effect rigidly connected to the shaft and acts simply as added inertia.

For general applications where several important frequencies of the vibration are present, predetermining the optimum performance of the dynamic type is very difficult, especially if taking the damping in materials into account is necessary. The performance, therefore, must be practically adjusted experimentally. With the Lanchester type, on the other hand, the performance can be analytically predetermined very accurately. The damped dynamic-type, when properly adjusted, will give the same result with a smaller inertia where only one frequency of vibration must be eliminated. But if more than one mode is present a single-damped dynamic-vibration absorber must have virtually the same inertia as the Lanchester type. For the automobile engine in which, without the damper, only one frequency of vibration of importance usually is encountered and where many machines of a single design are made and hence considerable experiment is admissible, the damped dynamic-type is doubtless the most suitable.

Some general statements might be of interest relative to the attachment of elements to the system of the dynamic-absorber type. In such systems the number of frequencies of important vibration is equal to the number of principal inertias in the system. Thus, as has been pointed out, if we add a dynamic-vibration absorber, we increase the number of natural frequencies by one. If we add n absorbers, we will increase the number of natural frequencies by n.

CHAIRMAN ALEX TAUB[5]:—I do not know whether Mr. Baker is aware of the instruments that are available for measuring and determining what is needed in the way of a counterirritant. Mr. Summers some years ago developed an instrument that he facetiously called the Wigglograph, and by that name it is still known. Determining where our critical speeds are is a short job with it, and with the guidance of the past work of Mr. Van Degrift and Mr. Summer we have no trouble in matching a dynamic vibration-absorber to our engines. From the standpoint of results per dollar, which after all is the final analysis, the dynamic type of damper undoubtedly meets our needs.

Model Gives Accurate Representation of Conditions

MR. BAKER:—On several occasions we have been questioned about the accuracy with which the model represents the condition it was intended to represent. The contention was that a discrepancy would be found between the theoretical results and the experimental results that were obtained on the model because of a supposed change in the amplitude of the disturbing moment.

To clarify the situation in this respect, the following remarks are included. The sketch at the left of Fig.

[4] See *Zeitschrift für Technische Physik*, 1929, p. 373, Fig. 9; also *Zeitschrift für Technische Mechanik und Thermodynamik*, 1930, p. 137; and *Transactions of the American Society of Mechanical Engineers*, vol. 50, paper APM-50-7.

[5] M.S.A.E.—Development engineer, Chevrolet Motor Co., Detroit.

1 is a schematic representation of the model (Fig. 9 of the paper). For simplicity, the system is shown translatory instead of rotatory. K represents the torsional stiffness of the shaft R of the model and is represented as being rigidly supported at the upper end since the large flywheel in the model has so great an inertia in comparison with the smaller one that it may be considered as stationary in space. The rectangle M represents the inertia of the smaller flywheel Q of the model, and k is the torsional stiffness of the coil spring A_1 of the model.

The meaning of the letters in both sketches is similar. The sketch at the right represents schematically the system which was assumed in the analysis and which the model was intended to represent. We need not, for this discussion, specify the nature of the friction force F except that it must be the same in both of the systems which we will compare. Further, we need not specify the displacement x_2 nor the force P except that they must be similar functions, as indicated in the sketches.

The question can be summarized as follows: Are we justified in calling these two systems, represented in the sketches, analogous; that is, will the motion of M be the same for both cases? For the force in the spring k depends not only on x_2 but also on x_1. Thus, only if the motion of M is small can the spring force be represented as $k\ X\ \varphi\ (t)$ or as similar to $P = P_o\ \varphi\ (t)$. If the motion M becomes appreciable in comparison with x_1, as it does in the model used, the force on the spring

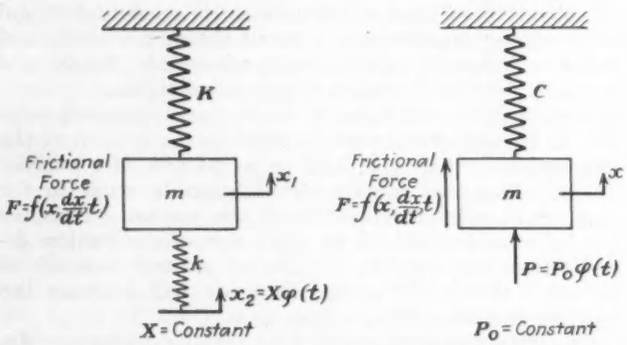

FIG. 1—(LEFT) SCHEMATIC REPRESENTATION OF THE MODEL USED BY THE AUTHORS AND (RIGHT) SCHEMATIC REPRESENTATION OF THE SYSTEM WHICH WAS ASSUMED IN THE MATHEMATICAL ANALYSIS

can obviously no longer be represented as $k\ X\ \varphi\ (t)$ and therefore is not the analogy destroyed?

To express the *total* spring force as independent of x_1 is certainly incorrect. But the *total* spring force is not what we consider analogous to the force P in the system shown at the right. We consider as analogous to P only the *component* of the spring force of k which is due to the displacement x_2. The rest of the spring force, that is, the component due to the displacement x_1, we consider added to the force due to K to make up the force analogous to that in the system at the right due to C. In this way, if we make $P_o = k\ X$ and $k + K = C$, we have two masses both subjected to exactly the same forces and, hence, if the same initial conditions obtain, the displacement will be equal at any time and the systems as represented are perfectly analogous.

The same result may be obtained by comparing the equations of motion of the two systems. In that shown at the right, the summation of forces gives

$$M\ \frac{d^2x}{dt^2} = -\ Cx + F + P \qquad (1)$$

Similarly, in that shown at the left

$$M\ \frac{d^2x_1}{dt^2} = -\ k\ (x_1 - x_2)\ + F - Kx_1 \qquad (2)$$

or

$$M\ \frac{d^2x_1}{dt^2} = -\ (k + K)\ x_1 + x_2\ k + F \qquad (3)$$

Substituting C for $k + K$ in Equation (3) and taking $k\ X = P_o$ (See expressions for P and x_2 in Fig. 1) Equation (3) becomes identical with Equation (1).

Can Calculate Performance of Dynamic Balancer

BORIS P. SERGAYEFF[6]:—Mr. Baker's statement that the advantage of the Lanchester balancer lies in the certainty of predetermined friction hardly can be justified, as applied to the dynamic balancer, as far as used by the General Motors Corp. As has been stated by Mr. Van Degrift, a mathematical analysis of the dynamic balancer and its general solution gives all necessary data to predetermine the performance.

The general solution of the dynamic balancer together with other arguments contains the constant of elasticity between the balancer and the shaft. In case of the Lanchester balancer this constant is equal to zero. Assuming that the other factors are equal, we can derive the performance of both balancers from this general solution and judge their respective advantages.

CHAIRMAN TAUB:—Mr. Sergayeff maintains that, with a little more effort, the dynamic type can be calculated just as well, if not as readily, as the Lanchester.

Dynamic-Type Damper Eliminates Torsional Vibration

R. K. LEE[7]:—The paper is very well written and shows that the authors have gone into the subject thoroughly; but, as in so many problems of this nature, many phases of the subject that have not been thoroughly exploited in this paper have a very direct bearing on the functioning of a crankshaft damper. The first thing apparent is that two of the important variables in the set-up—the relation of damper frequency and of moment of inertia to those of the crankshaft—have not been fully analyzed. I made a similar apparatus in which these proportions could be varied and found that, under the conditions cited in this paper, the authors are entirely right as far as they have gone, with the exception that I have every proof in the world that a simple dynamic-absorber does improve conditions in the variable-speed engine. In fact, in the last five years I have applied and assisted in the application of at least 50 different crankshaft-damper installations to engines of all designs and in automobiles, using both the friction-type damper and the dynamic-absorber type, and have yet to find an engine from which I cannot completely eliminate torsion periods with the dynamic-type damper. In one particular engine, 14 distinct periods occurring in the driving range without a damper were eliminated with the dynamic damper.

With the friction damper, the problem is much more difficult to solve. In an engine having a fundamental period at 4000 r.p.m., a friction damper was applied in which the spring pressure on the friction plates could be varied. Tests were run at each harmonic of the

(*Concluded on p. 66*)

[6] M.S.A.E.—Engineer and mathematician, General Motors Corp., Detroit.

[7] Development engineer, Chrysler Corp., Detroit.

Fuel Injection with Spark Ignition in an Otto-Cycle Engine

Additional Discussion of Paper[1] *by C. F. Taylor, E. S. Taylor and G. L. Williams*

H. E. A. RAABE[2]:—Extensive experiments along the lines indicated in this paper were conducted many years ago. The results, although very gratifying, have never been published because the proposal was considered too revolutionary to be accepted at the time. My first experiments in this direction, conducted about 30 years ago, would hardly be considered of value today, but tests made in 1921 indicated a fuel economy rivalling that of Diesel engines.

The latter experiments were carried on with a four-cylinder four-cycle L-head Continental engine, capable of a speed of about 2000 r.p.m. at its best, and the cylinders were 4½ x 4½ in., according to my best recollection. The object of the experiments was to demonstrate the practicability of using fuel-oil as an automobile fuel. The oil tried was a common 22-deg.-Baumé furnace oil.

Changes made in the engine were as follows: A separate fuel-pump was provided for each cylinder, the four pumps being built into one unit that included a driveshaft and regulating mechanism, the unit being mounted on the engine and geared to the camshaft. The stroke of the ¼-in. plungers could be varied by the regulating mechanism from 3/64 to ¼ in. A stroke of 1/16 in. was found to be sufficient at full load. Ordinary ¼-in. copper tubing was used for the fuel-feed lines. Fuel-injection valves of the type shown in Fig. 1, which was patented by me between 1915 and 1920, were designed for this engine and substituted for the caps over the exhaust valves. The feature of this valve was thorough atomization of the heavy fuel by air injection which was timed by the valve. The pump merely measured and delivered each charge of fuel to the valve, which was opened pneumatically by the injection air itself. The air was supplied by a small air-compressor that was belted to the engine. Air pressures from 25 to 80 lb. per sq. in. were used.

Fuel enters the valve at the connection *A* and fills the annular channel above the valve seat. From this groove the fuel is projected onto the valve disc through the annular port shown, the actual width of which is only 0.004 in. The air connection *B* communicated directly with an air manifold, and the interior of the valve body is under constant air pressure. The same pressure normally acts against the piston *C*, owing to the connection through the shallow groove *D*. As piston *C* is of larger diameter than the valve seat, the valve is held against its seat by air pressure until port *E* in rotary valve *F* registers with port *G*, allowing the pressure back of the piston to drop so that the valve is opened by the pressure in the valve chamber.

Timing is such that the valve is opened when the piston has completed about one-half of the compression stroke. The air rushing into the combustion-chamber carries with it the charge of fuel, which has been projected already upon the valve disc. To prevent the fuel from being forced into the combustion-chamber with very little atomization, 16 ports *H* are drilled from an annular groove in the valve seat to the interior of the valve body. A groove in the valve matches the groove in the seat. Air entering these 1/16-in. holes and im-

[1] This paper and the discussion on it at the meeting were printed in the S.A.E. JOURNAL for March, 1931, beginning on p. 345. The authors are members of the instruction staff of Massachusetts Institute of Technology.

[2] M.S.A.E.—Consulting engineer, Jersey City, N. J.

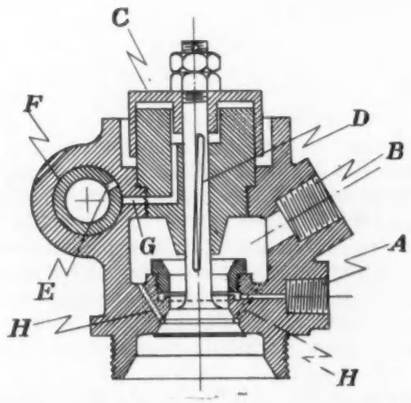

FIG. 1.—FUEL-INJECTION VALVE DESIGNED BY H. E. A. RAABE

A, Fuel Connection; *B*, Air Connection; *C*, Valve-Operating Piston; *D*, Shallow Air-Groove Communicating with Valve-Operating Piston; *E*, Injection-Timing Port in Rotary Valve; *F*, Rotary Injection-Timing Valve; *G*, Timing Port in Injection Valve; *H*, Air-Turbulence Ports

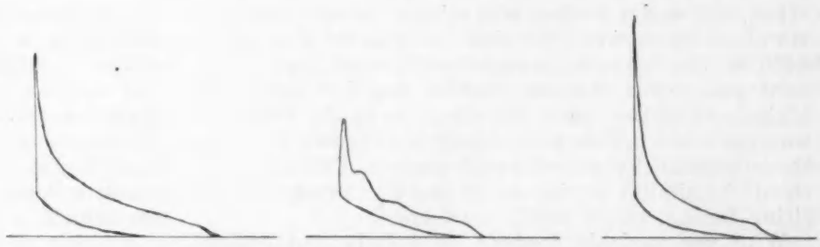

FIG. 2—INDICATOR DIAGRAMS FROM 5½ X 6-IN. TWO-CYCLE ENGINE WITH FUEL-OIL INJECTION DURING COMPRESSION STROKE

Pressure Scales Are Not the Same on the Three Diagrams. Data on the Various Diagrams Is as Follows:

	Engine Speed, R.P.M.	Compression, Lb. per Sq. In.	Maximum Pressure, Lb. per Sq. In.	Mean Effective Pressure, Lb. per Sq. In.	Indicated Horsepower
Left	500	86	394	70.5	12.7
Center	550	86	253	48.0	9.5
Right	500	74	347	58.2	10.5

pinging against the edges of the opposing grooves sets up a violent turbulence which causes virtually instantaneous atomization of the fuel. A test showed that atomization was accomplished in 0.0026 sec.

Rotary valve *F* was driven from the camshaft by gearing. Port *E* was cut spirally in the valve, so that shifting the valve axially would vary the time of injection from 45 deg. after bottom dead-center to 30 deg. before top dead-center. The best results were obtained by injecting at one-half stroke.

No change was made in the ignition system, which consisted of a Bosch magneto and Champion sparkplugs. The carbureter was left in place, so that comparative tests could be made. Free air could be obtained for the fuel-oil runs through a hole cut in the manifold, which could be covered during runs with the carbureter functioning.

Tests were carried on during eight months. At the end of this time, the porcelains of the plugs were found to be white, and no carbon deposit could be found in the combustion space. No detonation could be detected excepting when the injection was advanced to its earliest stage; detonation disappeared entirely when the injection was retarded to 60 deg. after bottom dead-center.

Tests with a prony brake indicated a gain of about 20 per cent in power with fuel-oil injection. The engine was started with gasoline, and the fuel-oil could be turned on as soon as the starting crank was dropped. The change back from oil to gasoline could not be made under load without stopping the engine. The exhaust was absolutely invisible, and the fuel-oil consumption was ½ pt. per b.hp-hr.

The construction of this engine was such that an indicator could not be attached, but tests were made about a year later with a two-cylinder two-cycle engine from which the indicator cards shown in Fig. 2 were obtained.

Recent Developments in Poppet Valves

(*Concluded from p.* 61)

the one to be used depending upon temperature. In many cases the use of ethyl gasoline alone will stop the trouble. This is probably because the products of combustion of ethyl gasoline form a thin coating on the valve seat that acts as an insulator between valve and block. Better cooling of the block seats helps greatly. The use of chromium-nickel or molybdenum alloy in the block helps in many cases. Substituting an angle of 30 deg. for 45 deg. at the valve-seat helps, probably because the quicker opening of the valve reduces the heating as the valve begins to rise. The use of a high combined-carbon content in the block has been useful in some cases.

The one sure cure is to use a seat insert in the block. Several materials are available. One of the best is Elkonite, a copper-tungsten mixture having the same coefficient of expansion as cast iron so that it can be installed with a press fit. An insert of fine-grained molybdenum-iron, high-speed steel, aluminum-bronze or Stellite puddled on steel can be used, but these must be held in the block on account of expansion variations. A good method is to bevel slightly the top of the outside diameter of the insert and roll the iron of the block over this bevel. The seats can also be screwed into place and locked by vertical pins.

Excessive oil in the combustion-chamber helps to prevent pick-up. Overhead oilers provide this, and adding oil to the gasoline in the tank also helps. A rich mixture tends to eliminate it.

The severe usage now imposed on truck and motor-coach engines has caused considerable annoyance from pick-up. Either reducing the temperature of the valve or block seat or using a seat-insert material other than gray iron is a solution of this problem. Cooling the valve with copper or sodium helps to overcome this trouble.

The use of vacuum cups is recommended for grinding valves, particularly for those with large heads. Spanner holes and screw-driver slots weaken the valve head and are likely to cause distortion.

Torsional-Vibration Dampers

(*Concluded from p.* 64)

crankshaft and a friction was set that would completely eliminate the period. Varying the friction from 130 to 1400 lb. was found necessary to obtain satisfactory results and, when the the friction was left as at the higher end of the range, the vibration at the lower end was increased. This is obviously due to the fact that the amplitude changes with each period. This condition should be similar to the one of merely varying the exciting force.

With the variable moment of inertia and spring-rigidity apparatus we determined that the best results were obtained when the frequency of the damper was fixed at two-thirds of the crankshaft frequency and the moment of inertia at one-sixth to one-quarter of the effective moment of inertia of the crank system. We found that, if we went higher than one-third of the effective moment of inertia, two sets of periods were introduced and that to eliminate both of them completely was impossible.

The functioning of a dynamic damper can be explained in many ways but the most logical one is that, where the difference in frequencies of the crankshaft and damper and more particularly in the proportions above mentioned is sufficient, the time element between the maximum-oscillation velocity of the crankshaft and that of the damper causes an out-of-phase relation which will not permit free harmonic movement of the crankshaft.

My tests indicate that using a built-up rate which does not follow a straight-line curve is desirable in the flexible member of the damper, so that in the lower harmonics the rigidity is not sufficient to add the moment of inertia of the damper directly to the crankshaft as in the high-friction type. In the friction damper, we obtained somewhat the same results by adding a member that, through its centrifugal force, varied the friction-plate pressure sufficiently to take care of the higher-speed harmonics.

Tires and the Rim-Riddle

Discussion of B. J. Lemon's Annual Meeting Paper[1]

IN THIS DISCUSSION some doubt is expressed that the problem of tires and rims constitutes as great a riddle as is implied by the author. His reply is that a study of the situation as summarized in Fig. 3 and Table 4 of the paper is evidence that "riddle" is too mild a term. Some of the author's statements in regard to the relative merits of rim and wheel types are qualified by one of the discussers, who also presents the advantages of the "Q.D." rim and clarifies the position of the wood wheel in relation to the drop-center rim. Other points covered refer to drop-center-rim rigidity, weights of rims, and well depth.

BURGESS DARROW[2]:—Mr. Lemon and I have been associated for many years in the standardization of tires and rims carried on by the Tire and Rim Association. His paper creates the impression that tires and rims constitute a tremendous riddle; but, in my opinion, it is not much of a riddle and is simply a straightforward development over the last 20 years, during which only three distinct types of rim have been involved.

The clincher rim came into use very early, probably reached its highest point of usage and development about 1910 to 1915, then decreased in favor until about 1925, and then became extinct. The straight-side flat-rim came in about 1907 and gradually increased in favor until, in 1925, it was in universal use in this Country. The drop-center rim for automobiles lay dormant for 25 years but, about 1925, it came back into usage and now is making a strong bid for universal use.

BURGESS DARROW

English, American, French and German rims have always differed to just about the same degree that these countries differ on the matter of weights and measures. If this is the riddle that Mr. Lemon refers to, I will admit that there have been some complications. But there has been no riddle in this Country, only a three-stage development.

The Tire and Rim Association, the standardizing body for tires and rims, was organized in 1908 and reorganized in 1911 for the sole purpose of prescribing standard rim-contours for this continent in order that rims might fit tires properly. I do not know where this Country would be today in the matter of tires and rims if it had not been for the functioning of this Association over the last 20 years.

The drop-center rim brings with it only two major tire-design problems. First, the tires are run without flaps, or tube protectors; second, exact control of the size and shape of the tire bead has become necessary, because the rim provides a certain width for the tire-bead seat, which was not the case in either the clincher or the flat straight-side rim.

The Tire and Rim Association has had a full line of drop-center rims on paper since April, 1928. This was long before the car manufacturers reached the point where they wanted to use these rims. Certain minor changes have been made in these designs in the last three years, and it was well that we made such changes before production really started.

Bearing in mind that tire-bead shapes and widths must be controlled, that each tire-size has a correct rim-size is obvious. I do not mean that, given eight tire-sections, there are eight different rims; because, in fact, only five rims are available for such a range of tire sections. I do mean that if the Tire and Rim Association says that 5.25 and 5.50-in. tires belong on the 3.25-E drop-center rim, the tire industry as a whole is behind such a recommendation and wants all 5.25 and 5.50-in. tires on that size of rim. The tire industry does not want larger tires on such a rim.

I have a plea to make; it is that car engineers follow the recommendations for rim and tire sizes which are given out by the Tire and Rim Association, and that they do not take liberties in the way of over-sizing tires, now that we have the drop-center rim to contend with.

B. J. LEMON:—Answering Mr. Darrow's conclusion that the paper creates the impression that tires and rims constitute a tremendous riddle, whereas not much of a riddle exists, I can say that perhaps the picture of tire and rim equipment is simple to one as familiar as he is with its details. This simplicity, however, is confined to perhaps 100 experts in the tire and the wheel industries. Many car-chassis engineers consider tire and rim sizes and types as extremely confusing. A study of the situation as summarized in Fig. 3 and Table 4 of the paper is evidence that "riddle" is too mild a term.

Comparison of Rim Weights

A. S. VAN HALTEREN[3]:—I agree with Mr. Lemon in regard to the trend in rim design, but wish to qualify some of his statements in regard to the relative merits of rim and wheel types. In my opinion the trend toward the drop-center rim on demountable wheels for the lighter cars has not been because the drop-center rim functions better, but rather because it is lighter and can be produced for less money.

[1] The paper was published in the March, 1931, S.A.E. JOURNAL beginning on p. 332. Mr. Lemon is a member of the Society and field engineer for the production development division of the United States Rubber Co., Detroit.

[2] M.S.A.E.—Manager, development department, Goodyear Tire & Rubber Co., Akron, Ohio.

[3] M.S.A.E.—Executive engineer, Motor Wheel Corp., Lansing, Mich.

A. S. VAN HALTEREN

A comparison of rim weights covering three types of rim for tire sizes ranging from 5.00 to 7.00-in. sections shows an advantage in weight for the drop-center rim over the wire-wheel Q.D. rim of from 2 to 3 lb. per rim, or an average of 2.5 lb. per rim in favor of the former for use on wire wheels. (See Fig. 1.) The cost advantage is more than in proportion to the weight advantage in the smaller sections, which permit the use of strip stock as compared with two special sections for the Q.D. rim. I have gained the impression that the majority of engineers would prefer to continue with the Q.D. rim, and that the difference in cost has been the most important factor.

The appearance of wheels of larger diameter has been improved by the use of the drop-center rim, because the effective depth and the width of the tire have been increased. The reduction in the inside diameter of the rim has permitted a reduction in the number of spokes, which has helped to popularize the use of drop-center rims through further reductions in cost. In other words, I believe that the small percentage of squeaky side-rings would be tolerated except for cost.

The first detachable split-flange type of rim was called the Goodyear No-Rim-Cut Rim. This type has gone through 18 years of development, which is an enviable record, and has reached a state of perfection that can be appreciated only by those who have been intimately responsible for the development. The drop-center rim is now going through the development process, and time will be required to make it as satisfactory in every respect as is the detachable-flange rim.

Advantages of the Q.D. Rim

The Q.D. rim is not directly responsible for the entrance of water into the tire. Water enters between the rim flanges and the tire casing when the casing is pulled away from the side flange as the car rounds a curve. Moisture is held to the minimum on the drop-center rim by a close fit between the tire bead and the ledge of the rim, which is an important advantage for that rim.

I fail to understand why a better-balanced, truer and perhaps stronger wheel is obtained through substituting a drop-center rim for a Q.D. rim. In fact, a stronger wire wheel can be built with the latter, because the drop-center rim limits the number of spokes. The practical limit is 40 spokes and the maximum is 48, which is an important consideration as regards strength and appearance of wheels on cars in the higher-price class. This disadvantage, combined with the fact that it is impossible to maintain treads without major axle-changes when large brake-drums are used, will delay the use of the larger-section drop-center rims. Wire wheels with 4.00-in. drop-center rims are being used with success in production, but the subject of appearance is still an open question. Another debatable question is whether or not the mounting and demounting of tires has been facilitated by the use of drop-center rims in the larger sections.

Drop-Center Rims for Wood Wheels

To clarify the position of the wood wheel in relation to the drop-center rim, I may state that we are building a competitive wood wheel, demountable at the hub, having the spokes assembled directly into the base of the full drop-center well. (See Fig. 2.) Since wire wheels have been announced as standard equipment on a number of cars, the demand for the wood wheel has increased very decidedly, so that the wood wheel will be an important factor in encouraging the use of drop-center rims on the lighter cars. The steel wheel lost its prestige when it was offered as standard equipment with no extra charge.

It will also be interesting for Mr. Lemon to note that 50 per cent of our company's 1930 passenger-car production was wood wheels and, if the semi-drop-base split-rim can be classified as a drop-center rim, indications are that over 50 per cent of our 1931 passenger-car-wheel production will be on drop-center rims having wood spokes. We have one patron who built over 50,000 cars in 1930; he specifies that 60 per cent of his company's demountable wheels have drop-center rims and wood spokes. We have also several other large accounts with companies that are using more than 50 per cent of wood wheels equipped with semi-drop-base split-rims.

This rim follows the exact contour of the full drop-center rim and enjoys all of its advantages, including wide sections and the tight-fitting bead-seats used on the full drop-center rim. This semi-drop-base split-rim is provided with a collapsing joint-plate, and the tires can be mounted on the rim and removed without the use of tire tools. (See Fig. 3.) The well is too shallow to allow a flat tire to throw off the rim when in the assembled position on the wheel. For demountable-at-the-

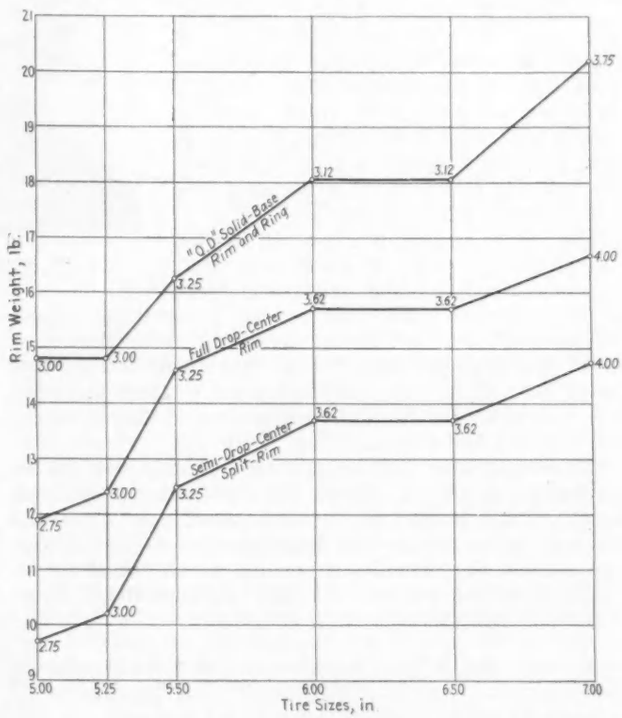

FIG. 1—COMPARISON OF RIM WEIGHTS COVERING THREE TYPES OF RIM. THE RIM SIZES IN INCHES ARE DENOTED ON THE CURVES

felloe wheels, we believe the semi-drop-base split-rim is more desirable than the full drop-center rim, because we can build a felloe having ample width for the spoke seat and the rim does not necessitate any compromise to obtain a true safe mounting with minimum clearances and ample strength. This is the lightest and most economical equipment that we have been able to design.

In conclusion the drop-center rim, including the semi-drop-base split-rim, will, in my opinion, eventually solve the rim riddle. It is desirable because it permits rims of wide section to be used most economically for both the demountable-at-the-hub and the demountable-at-the-felloe wheel.

QUESTION:—How does the drop-center rim affect the limits of the diameter of the inside of the tire and the rim? Is holding to closer limits necessary, or can a wider variation be allowed?

MR. LEMON:—We have the same tolerance on tire beads at present that we had when the flat-base rims were in greater use. We have used a so-called "drop toe," which puts the toe under compression so that it hugs the rim better than if we had no soft rubber toe or no compression. The rim has been enlarged so that it comes up into the tire. We have not changed the tire, but we have increased the diameter of the rim to secure a better fit. Except for a taper bead and soft toe, the tire has not been changed.

F. S. DUESENBERG[4]:—The Dayton Wire Wheel Co. recommended the drop-center rim about six years ago. The general impression seemed to be that the tire manufacturers did not believe it was good practice, and many persons said that the rim would spread. That might be true with the full-section drop-center wheel; but I have

F. S. DUESENBERG

always felt that this difficuty might be overcome by using better rim-material.

I remember that we had special tools made in 1918 and 1920 to enable us to roll a rim of better material. We paid for some of the dies at the time our cars were first exported to France. We had some molybdenum rims made which were much lighter and were strong. The objection on the part of the rim manufacturer seemed to be that the material was too hard to handle. But I think that using very much better material for the drop-center rim should be possible because rolling the small channel that holds the locking ring, as is the case with flat rims, is unnecessary. Using better material for the drop-center rim would be of great advantage, provided that the tendency toward rim-spreading is not a serious factor.

C. L. EKSERGIAN[5]:—We have given considerable attention to the point brought out by Mr. Duesenberg as regards rigidity. I think that whether we can actually utilize the strength capacity of the present low-carbon-steel rim, let alone that of an alloy rim, is open to question. In other words, in addition to the carrying capacity of the rim with respect to both the axial and radial components of loading, we are concerned with the deformation that the rim undergoes under this loading. One of the outstanding contributions of the drop-center rim,

[4] M.S.A.E.—Vice-president in charge of engineering, Duesenberg, Inc., Indianapolis.

[5] M.S.A.E.—Chief engineer, Budd Wheel Co., Detroit.

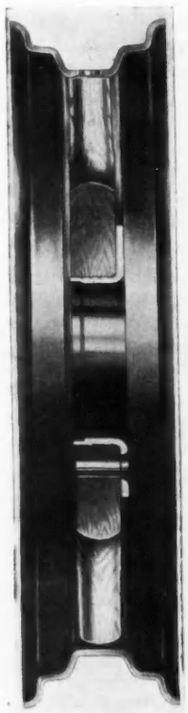

FIG. 2—DROP-CENTER-RIM DEMOUNTABLE WOOD-WHEEL SPIDER

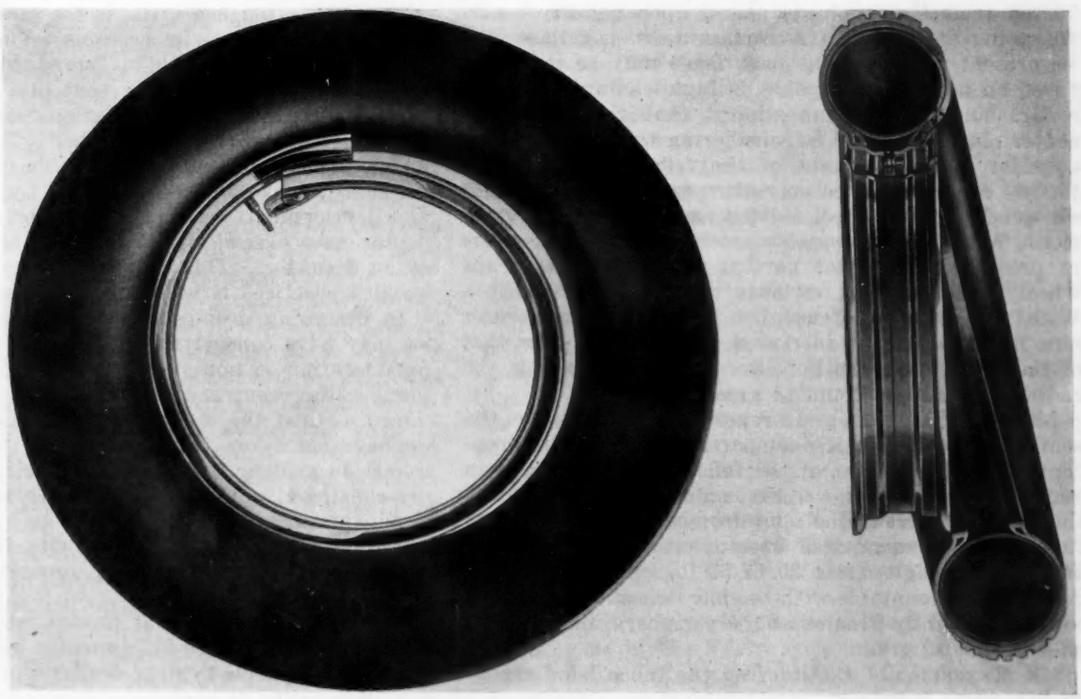

FIG. 3—SEMI-DROP-BASE SPLIT-RIM COLLAPSED FOR ASSEMBLY IN THE TIRE

particularly when applied to the wire wheel, is the fact that the rim section has a very high section-modulus and, therefore, we can count on the maintenance of a truer circle at all times.

Any slight deflection of the rim naturally imposes an elastic strain-variation on the spoke of a wire wheel. Considering an ordinary wire spoke which may have an average length of say 7 in. and a working stress of 60,000 lb. per sq. in., the complete elastic strain-variation cannot be more than 0.0014 in. Assuming that an initial strain must be imposed on the spoke, a proper balance between rigidity and resiliency in the rim is desirable in order that the change in distance between shell and rim at any spoke be within the elastic strain-range of the spoke. In other words, the spoke itself, preferably should have sufficient elasticity to absorb length variations incident to the alternations of loading that attend the spoke as it passes through 360 deg. In this manner a definite bearing can be maintained between spoke head and shell, and nipple head and rim. Obviously, this maintains, at all times, a complete tie-in between shell spoke and rim, which is desirable.

Again, inasmuch as the fatigue limit is a function of the amplitude of the stress alternation, keeping the stress alternation and, therefore, the strain alternation in the spoke to the minimum is desirable. Inasmuch as the amplitude of this strain alternation is so affected by the rim deformation, we are naturally considerably concerned with the balance between rigidity and resiliency of the rim.

Generally speaking, the rim stresses as defined by the above considerations are considerably lower than those defined by the capacity of low-carbon steel, so that no advantage would accrue from employing a material having higher capacity at a higher cost and attendant greater difficulties in fabrication when this added capacity cannot be utilized.

Complete rigidity is not desirable, as might be inferred from the emphasis placed upon rigidity in the foregoing statements. A certain resiliency must also be present in order that peak loads may be more diffused on neighboring spokes in high-loading zones.

Mr. Van Halteren mentioned that the semi-drop-center rim is lighter. In considering this rim, we must consider also the weight of the felloe band. A true picture can be obtained only after considering the over-all weight of the wheel as well as the radius of gyration. With the high-speed acceleration that we require at present, the greater portion of the weight of the wheel should be kept as near the center as possible. With the combined felloe band and semi-drop-center rim, not only does an increased weight result over that of the drop-center rim but also, generally speaking, the radius of gyration would be greater.

MR. VAN HALTEREN:—In regard to weights, when the semi-drop-center rim is compared with the full-drop-center rim, the weight of the felloe should be added in each case to make the weights comparable. Concerning the flywheel effect of the semi-drop-center rim, it is less than for any demountable wheel; that is, the semi-drop-base wheel weighs from 30 to 50 lb. less per set than does the demountable-with-the-hub wheel. While the weight is slightly greater at the periphery, the flywheel effect is not so great.

MR. EKSERGIAN:—Considering the felloe band simultaneously with the semi-drop-center rim is necessary because the semi-drop-center rim is essentially a demountable rim that requires a felloe band for the completion of the rim assembly. The full-drop-center rim, on the other hand, is not exclusively a demountable rim, being in fact usually employed in a demountable wheel in which no felloe band is present. The only occasion for comparing the two rims, each in combination with a felloe band, is when the full-drop-center rim is used as a demountable rim, which is not so prevalent at present. Accordingly, making comparisons regarding the semi-drop-center rim with felloe band versus the full-drop-center rim without felloe band is fair in the main.

When comparing the demountable wheel, with drop-center rim and without felloe band, with the demountable-rim wheel, employing the semi-drop-center rim with felloe band, the over-all weight of the wheel becomes a question of wheel design as to which wheel will weigh less. Everything else being comparable, the demountable wheel should be lighter by virtue of the absence of the felloe band, and our experience is that this result actually can be accomplished.

L. V. CRAM[6]:—Concerning Mr. Duesenberg's remarks about weight, our experience until lately has been with wire wheels as special equipment only. Last year we had a considerable amount of spoke breakage at high mileage.

Our company has succeeded in developing a rim section that has increased the spoke life about three and one-half times that of last year. This necessitated a slight departure from rim standards, which has made some trouble for the tire manufacturers, but the point is that the greatest value per dollar to the customer probably will come ultimately from this development. We are working in cooperation with the tire companies to develop means of mounting that will care for this slight variation from the standard.

H. PARTENHEIMER[7]:—One phase of the subject, which has not been touched upon, is the interpretation of our present drop-center-rim sections. They are sometimes referred to as July, 1930, "standards" and again as "standard" drop-center-rim contours. Distinctly, they are not Tire and Rim Association "standards" at present, as I interpret "standards." They are "recommended practice," and I believe this is a very wise distinction to make at present in this transitional stage of rim development, because the present drop-center well-depths have been designed for tires of not less than 18 in. in diameter. This means that our present "recommended practice" is based upon our past experience.

In designing drop-center rims of smaller diameters, we may have considerable trouble in the future if due consideration is not given to the well depth. It may sound rather contrary to our position, as we have cautioned against the well that is unnecessarily deep; but we have not taken the stand at any time to go to extremes in shallow wells. We believe that, with certain tire-construction features, shallower wells can be used to advantage. Our aim has been to work with the car manufacturers in keeping step with their car development so that we would not put unnecessary obstacles in their path.

I wish to point out that anyone working on 17 and 16-in. and perhaps 15-in. diameter rims should tie-in with the tire people to make certain that the well depths, according to the present recommended practice, will not give trouble due to the stiffer bead-sections, which are

(*Concluded on p. 72*)

[6] M.S.A.E.—Assistant chief engineer, Chevrolet Motor Co., Detroit.

[7] Fisk Rubber Co., Chicopee Falls, Mass.

Utilizing the Latent Heat of Cooling Water

Supplemental Discussion of Adrian Hughes, Jr.'s Transportation Meeting Paper[1]

WILLIAM G. WALL[2]:—In going over Mr. Hughes' paper on the Foutz cooling system, I find it very interesting. This system does look quite complicated mechanically, however; much more so than other steam-cooling systems. Although I agree with Mr. Hughes that very little can be hoped for from steam-cooling, I do not see that the Foutz system is much better, and the fact that so few vehicles have been equipped with any of these systems seems to show that the merits, if any, are rather negligible.

The steam-cooling system has been discussed so often that it is hardly necessary to enter into its advantages or disadvantages. The only advantage is a smaller radiator, and the disadvantages are very many.

I must take issue with several statements in Mr. Hughes' paper which it hardly seems possible can be borne out by the facts. In the first place, he states that he is making use of the latent heat of water, yet he says, as I understand him, that the water is always liquid and does not boil. The definition of latent heat is, "The heat required to change a body from a liquid to a gaseous state." If water is not changed from liquid to steam or vice versa, use cannot be made of the latent heat of vaporization.

Another statement is that by deaeration the boiling point of water is raised 58 deg. fahr. above its atmospheric boiling-point. I understand that some such phenomenon has been recorded but have never heard of securing it in practice and it certainly does not agree with the steam tables. The boiling point of water cannot be raised without raising the pressure, and the amount that the pressure is raised is given in the regular steam tables.

Also, in regard to the pressure exerted by the steam in the Foutz system, suppose we assume, as Mr. Hughes says, that this acts on the water flowing to the pump. If this is the case, how does he take care of the reaction of this action, which would certainly exert a similar pressure on the water coming from the pump?

The charts which Mr. Hughes submits to show the advantages of this system are not very convincing, as in none of these charts does the cooling water reach a really high temperature; in fact, in one of the diagrams the temperature does not rise above 165 deg. fahr.

Mr. Hughes also makes certain statements with regard to ordinary water-cooling systems. One of these is that the water circulation ceases when the temperature of water entering the pump reaches 180 deg. fahr. If this statement were true, a great many vehicles that are running on the road today would be laid up. Any kind of a meter in the water line would easily disprove this statement conclusively.

The author further states that in the Foutz system the water-flow increases very much with the temperature, whereas, in the ordinary cooling-systems, it decreases and finally ceases; and he endeavors to show this by mathematics based on the measure of pressure in the water line, whereas, any type of meter would prove or disprove it very conclusively, as already remarked. If such simple pressure measurements could be used to determine water-flow, much of our laboratory work would be simplified, but, unfortunately, such measurements are not correct.

So, with the questionable advantages, together with the complications and the additional cost of a system of this kind, it does not look at all promising.

Author's Answers to Criticisms

ADRIAN HUGHES, JR.:—The Foutz system is not a boiling system like all steam-cooling systems with which Mr. Wall is familiar. It is a system circulating water above its atmospheric boiling-point while in a liquid state through the engine jacket and then effecting vaporization and separation of the water from its vapor in the upper radiator-tank, which becomes a steam dome. During this change of state, a process of proportional vaporization takes place by which the latent heat of vaporization of the liquid is utilized, the aqueous vapor entering the condenser while the portion of the water that remains unvaporized continues its circuit through the water legs, the condensate returning to the circulation, thereby adding to the cooling-water its sensible heat.

The inventor was not desirous of placing in use a large number of the systems until all mechanical weaknesses in radiator structure had been overcome. Radiator condenser-structures as first built would not withstand the high temperatures, and he definitely knew at the beginning of the first installations that the soldered structure of conventional radiators would not stand up in this service for long.

The Foutz system is different from other liquid cooling-systems. It is not a system for *maintaining boiling water in the engine jacket*, but is just the reverse. Therefore it has none of the disadvantages of steam-cooling. Mr. Wall misses the point of vaporization or change of state of water which occur in the place prepared for it; that is, in the separating chamber, or steam space, and *not* in the engine water-jacket.

The boiling point of water can be raised without raising the aqueous pressure. However, in the Foutz system the pressure is at all times greater than the boiling point of water. So Mr. Wall's assumption about the steam table is correct.

Relative to the vapor-pressure effect existing in the steam space in the Foutz system, the pressure on the pump inlet and discharge outlet is the same, but in this case the liquid is in motion and, when pressures are positive or negative forces, the flow will be in accordance with the difference in pressure. Hence the direc-

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[1] The paper, together with discussion on it which was presented at the meeting, was published in the S.A.E. JOURNAL, January, 1931, p. 66. The discussion herewith was submitted later. The author of the paper is superintendent of bus transportation, United Railways & Electric Co. of Baltimore, and is a member of the Society.

[2] M.S.A.E.—Consulting engineer, Indianapolis.

tional forces and the results attained are exactly what would be expected.

Relative to the low temperatures shown in Fig. 3—Comparison of Cooling-Water Temperatures in Two Motorcoaches (See S.A.E. JOURNAL, January, 1931, p. 70): Although the condenser constitutes 40 per cent of the total cooling area, the increased velocity of fluid flow through the water sections of the radiator keeps the water temperatures too low to raise the point of vaporization. The system can be designed to produce any desired temperature.

In another case, a Foutz-system radiator designed to contain 102 sq. ft. less cooling surface than that provided in the bus builders' conventional radiator and containing a condenser of 42½ per cent of the remaining total, the circulation of the water was so rapid, due to the air-pressure effect on the surface of the liquid, that, to effect deaeration and raise the jacket temperatures high enough to produce steam to enter the condenser, it was necessary to close off with a shield 50 per cent of the remaining water-cooling section. This is stated to show that the results obtained with the Foutz system two or three years ago must not be considered a criterion of what the system is today. High-temperature operation has been accomplished with engines of 855-cu. in. displacement, doing work of absolutely the hardest and most continuous kind possible, at temperatures of 220 and 230 deg. fahr.

With properly built radiators that are now available, results are being obtained in practice exactly in accordance with the claims made in my paper. To conceive of the Foutz system as a steam-cooling system is a mistake. Steam-cooling systems do not work, and the Foutz system does work; it stands upon its performance. There are no complications, and the additional cost is very small. Careful study of the system would convince Mr. Wall or anyone else who would take the trouble to investigate it thoroughly.

Tires and the Rim-Riddle

(*Concluded from p. 70*)

naturally more difficult to deform from their circular shape in the application of the tire to the rim.

Another problem on which I believe the car manufacturer should work very closely with the tire industry is in the trend toward more riding-comfort, which naturally brings up the point that tires having larger cross-sections may be asked for on the smaller rim-sections.

I interpret Mr. Lemon's "tire riddle" as referring to meeting the demand in the field if various cars come out equipped with double or triple over-sized tires. Therefore the tire industry should be tied-in very closely with all of these proposed moves so that the tire engineers can give proper consideration to designing their tires to meet the existing conditions as well as any new ones that may come due to car development. In this connection I wish that we might hear from some of the car manufacturers as to the possible trends in that direction.

Functions of an Engineering-Development Department

A BRANCH of our engineering organization which is extremely important, because it relieves the organization of a mass of routine and follow-up work, is the so-called "engineering-development department." The head of this department bears the title of director of engineering operations. Some of the functions which devolve upon him and a corps of 15 men are the procuring of all materials used to build up experimental bodies and chassis and the circulating or "broadcasting" of all proposed engineering changes to the production, planning and purchasing departments. By so doing, these departments can hold down commitments and manufacturing pending regular changes in design and specifications which follow some time later. The use of this system results in great financial savings and the introduction of improvements at an earlier date than would otherwise be possible.

Representatives of this department also conduct quality meetings at the various plants. These meetings are attended by representatives of the service, production and engineering departments. All complaints pertaining to the product of the particular plant are brought before this meeting to be discussed, and some action is taken. If the fault is engineering, it is referred to the design or experimental departments for action; if the fault is production, it is referred to the production department for correction. The proceedings of these meetings are recorded and the items are continued from meeting to meeting, being checked up each time until a satisfactory report can be made on each of the items before it is eliminated from the minutes. By means of his system, rapid and positive action is assured in connection with all complaints that come to our attention.

This department also absorbs a large number of other functions of a routine nature; in fact, everything that is irksome to engineers is thrown over to it.—From an address before the Canadian Section by H. T. Woclson, chief engineer of the Chrysler Corp.

Diesel Engines Evaluated

18th National Aeronautic Meeting Paper

By H. M. Crane[1]

SO MUCH INTEREST is being shown in the Diesel engine, both by builders of powerplants and by producers of fuel, that I shall try to take it apart and reduce it to its fundamentals.

Originally conceived as a constant-pressure engine, it was subject to sufficient irregularity in operation so that provision had to be made for occasional abnormal explosion pressures of from 1000 to 1500 lb. per sq. in., thus causing the engine to be heavier. It was natural, also, that the engine could be built in large slow-running units, because of the influence of steam-engine practice and because it is much easier to control the injection at low speed. This was the status of the Diesel engine at the time of the World War.

Air injection was the obvious way of securing the best possible mixture. However, many designers became discouraged with this method, on account of the expense, power loss and difficulty involved in compressing air to the high pressures required and the compression explosions caused by irregularities in lubrication. Such considerations caused frequent attempts to inject the fuel directly into the combustion-chamber.

The difficulty of direct injection can be visualized by considering that the mixture in the Otto-cycle engine is being formed during 180 deg. of crankshaft rotation in the inlet stroke and an additional 180 deg. in the compression stroke, with favorable conditions as to turbulence and temperature. In the Diesel engine, no mixing can be done except between the beginning of the power stroke and the time when injection must cease to prevent burning in the exhaust; probably not over 10 or 15 deg. instead of the 360 deg. of the Otto engine.

Shortly after the War I was called upon to inspect and report upon an engine which included a high-pressure and a low-pressure cylinder. The low-pressure cylinder was used both as a supercharger and for expansion of the charge. The objects of supercharging, according to the inventor's explanation, were to obtain a combustion-chamber of a shape that was favorable to injection and mixing of the fuel with the air, and to secure enlarged cylinder capacity without the weight ordinarily required for high explosion pressure.

As an outside observer, the author states his own opinions as to the future of Diesel engines, unless that future is modified by the development of new structural materials or new fuels. They are to the effect that the original Diesel cycle, involving constant-pressure combustion, is not proof against excessive pressure rise. Since structural provision must be made for the higher pressures, it is good economy to utilize such pressures. The weight per horsepower of the engine must therefore be greater than that of a gasoline engine, and explosion roughness must be expected.

The larger automotive units, particularly for lighter-than-air craft, are visualized as the best field for the automotive Diesel engine. It can win its way only as engineers see advantages in factors such as low fuel consumption and reduction of fire hazard to be great enough to overcome the handicaps of weight and cost. Meanwhile, developments of the gasoline engine may rob the Diesel of some of its advantages, fuel economy in particular.

Discussers showed interest in the relative freedom of the Diesel-engine exhaust from carbon monoxide, which was explained by the excess of air that is usual in Diesel-engine cylinders and discounted by the tendency of Diesel engines to smoke when running at full power.

High Explosion Pressure Necessitates Weight

We found that the engine was not operating on what was then known as the Diesel cycle, as the explosion pressures were 1000 to 1200 lb. per sq. in. Mechanical difficulties also were evident, and the engine never became successful.

This was the earliest engine about which I know in which such high explosion pressures were utilized. Since the time of that engine, designers have recognized that high explosion pressures in a compression-ignition engine cannot be entirely prevented, and therefore that the pressure might as well be utilized to increase the power of the engine.

As soon as the problem was attacked from this new angle, a change in the system of injection became possible so that injection can be started much earlier, with a better chance of utilizing the available air. The optimum compression pressure may be different and may be considerably higher than the pressures originally used. The types of injection mechanism and spray are also open to change.

Regardless of development with respect to compression and injection, an engine of this type will compare unfavorably with the normal Otto-cycle engine in specific weight and in smoothness. Considering the weight of the engine and fuel, it is necessary to find whether a sufficient saving can be made in the weight of the fuel to more than counterbalance the additional weight

[1] M.S.A.E.—Technical assistant to president, General Motors Corp., New York City.

of the engine. There is no reason to expect any advantage for the Diesel engine in fuel consumption except that due to its higher expansion ratio, and improvement in the fuel-consumption characteristics of the Otto-cycle aircraft engine may be possible through a higher expansion ratio.

Small Diesels Require Refined Oil

The expense of widespread distribution is an important element in the cost of motor-car gasoline. If aircraft required a special fuel, its use would be restricted to landing-fields and a limited number of other places, so that the cost of distribution would be much less than that of motor-car fuel.

Automotive engineers should investigate the actual fuel requirements of a small high-speed Diesel engine. The ideas of otherwise intelligent people on this subject are astounding. Roger Babson, for instance, told me within 1½ years that he understood that Diesel engines run on crude oil, just as it comes from the ground, regardless of its source and the amount of sand it contains. As a matter of fact, there is some reason to believe that the limitations of fuel needed for the high-speed Diesel engine may require an even higher grade of refining process than is required for motor gasoline. Gasoline has unusual value because of its availability for use in prime movers; otherwise it would not sell at a price that is so much higher per British thermal unit than does the so-called Diesel-engine oil.

There was very stiff competition between the radial air-cooled engine and the water-cooled engine for aircraft about five years ago. Unquestionably the battle would have been decided in favor of the water-cooled engine if it had not been possible to develop higher rotative speeds in the radial engine than were possible in the early days. At first no one could conceive of operating a radial air-cooled engine of military type, having a two-piece crankshaft, at 1500 r.p.m.

The question of speed is introduced because of its bearing upon the availability of the Diesel engine. An economical Diesel engine might be able to run at 1500 r.p.m., but there would be little chance of obtaining the same mean effective pressure and efficiency of operation at this speed as at lower speeds.

Difficulties of Attaining High Speed

The crankshaft, connecting-rods and similar parts of the Diesel engine are no different from similar parts of a gasoline engine operating under the same explosion pressure; any good engineer can design them. However, the experience of most of us who have worked with engines is that the explosion pressure and compression pressure have a tremendous influence on the ease with which tightness of the valves, pistons and piston-rings can be maintained. An increase in the compression of the Hispaño engine from 4.8 to 5.3:1 became necessary at the Hispaño-Suiza plant in New Brunswick, N. J., during the War. As a result, not a single engine passed its tests during the next two week. Burned pistons and every other imaginable difficulty appeared because of this relatively small increase in pressure. Diesel engines will require, as compared with gasoline engines, heavier pistons, more piston-rings and generally more expensive construction to retain the high explosion pressure with the same degree of reliability and the same cost of upkeep.

The aircraft-engine carbureter is a very simple mechanism, with virtually no moving parts. Its pressure drop is low, and conditions favor high volumetric efficiency and accurate metering. The designer of a high-speed Diesel engine is in a very serious quandary. Minute quantities of fuel are required at part throttle, the fuel is actually somewhat compressible and is hard to handle at the pressures of 4000 to 5000 lb. per sq. in. which are required. More important still, it is difficult to control the injection sprays at widely varying speeds. The accuracy of workmanship required in the pumps is away beyond that required in ball-bearings, and the acceleration difficulties in handling the oil are hard to conceive.

Parts of the cylinder-injection apparatus are so small that minute inaccuracies result in large percentage errors in the amount of fuel delivered. The complication of the pumping system is far greater than uniformed engineers might expect, because of the high pressures, the small quantities involved and the stringent requirements as to accuracy. One of the best-known injection pumps, which was tested at Langley Field in June, 1930, made far more noise than would be passed in the inspection of a Chevrolet automobile engine. No purchaser would accept a car having an engine that made as much noise as this pump, and no motor-car engineer would accept a type of engine which runs with the roughness that seems to be unavoidable in a Diesel engine.

I have been on several Diesel yachts and observed built-in pyrometers as a regular part of the engine equipment. The pyrometer can be connected by a switch with the exhaust port of any cylinder, and it is customary for the engineer to observe the temperature at each exhaust port to check the adjustment every time the speed is changed. Otherwise, extremely irregular operation will ensue.

Aircraft Field for Diesel Engine

The Diesel engine is far from being an impossibility; it is a probability, more particularly in the larger units. What is probably its most profitable field, the lighter-than-air ship, has not yet been successfully invaded by it, in spite of the English attempts with the Beardmore and the German with the Maybach engines. The airship may be required to carry fuel for a flight of 100 hr., while the airplane seldom flies longer than from 4 to 10 hr. The airship also is a larger unit which can utilize a considerably larger powerplant than the airplane, and flexibility in engine speed is far less important.

If the compression-ignition engine developing high explosive pressure is designed for a reasonable degree of economy, it will be far heavier for the available horsepower than the corresponding Otto-cycle engine in even its present form, and it will be considerably more costly to construct and will require a considerably higher degree of skill and probably higher cost in maintenance. If mean effective pressures considerably lower than that of the gasoline engine are acceptable, the Diesel engine may be comparable with the gasoline engine in other respects. Aircraft engineers can best decide how much weight they can afford to add to the powerplant to attain certain desirable results, such as reduction in fire hazard.

I cannot see that either engine has much advantage in regard to complication. Much is made of the complication of the magneto, but many years of experience with electric ignition gives me the opinion that it is not at all a serious problem; I believe that high-pressure fuel-injection is far more difficult.

The foregoing has had to do chiefly with the design, construction and application of the engine. A much more important question is the actual practical service that the engine will give. The same applies in the motor-car business; proving-ground tests may prove successful, but the final judgment on a car comes only after it has been in owners' hands for from six months to a year. Is it possible to build small injection-systems to give the pressures required and to continue in operation through a long period with a wide range of fuels? If this is not possible, the engine will not stop completely but it will operate in an irregular and highly uncomfortable manner, and this condition will be hard to correct. Irregular torque reaction is the hardest thing we have to deal with in automobile engines. The smoothness of the Cadillac-16 powerplant is due entirely to the tremendous advantage of reducing the irregularity in torque reaction to the minimum, because the mechanical balance of this engine is probably not as good as that of the eight-cylinder engine of the same make.

I have a feeling that, while efforts are being made to develop the Diesel engine into a successful competitor of a gasoline engine for automobiles, fuels will be produced that will accomplish the same purpose in an easier and better way.

THE DISCUSSION

A. H. VANCE[2]:—Relative conditions as to combustion in the two types of engine are of interest. We are told that the Diesel-engine exhaust contains only about 0.5 per cent of carbon monoxide, while the ordinary automobile-engine exhaust has as much as 2 to 9 per cent of this gas. Is the short time that is available sufficient to form the homogeneous mixture that is needed for complete combustion?

I have run quite a number of exhaust-gas analyses on carbureter-type engines, and the lowest proportion of carbon monoxide I have ever found was 2 per cent. Possibly even heavy fuel could be used in an Otto-cycle engine if a homogeneous mixture were secured, but neither gasoline nor kerosene gets broken up in an ordinary engine. Either of these must first be gasified and then mixed thoroughly with the air. Only 1/50 sec. is available during one revolution of the crankshaft at 3000 r.p.m. That is not time enough to produce the quality of mixture which is required for complete combustion, but it may be possible to secure it in some way other than the method now used.

Air in the cities, and probably in the whole Country, is being polluted with this poisonous gas. Any information will be useful as to why the Diesel engine, in spite of the small time available for mixing, produces so much less monoxide than does the ordinary automobile engine.

Smoke Emitted at Heavy Load

H. M. CRANE:—Figures on carbon monoxide remind me of some of the steel specifications we saw during the war. They might call for steel having an elastic limit of 180,000 lb. per sq. in. and an elongation of about 30 per cent. The only way that such specifications could be met was by using separate test-specimens that had been heat-treated differently. Low percentages of carbon monoxide are obtained only with little or no power output. A small Diesel-engined boat which was carrying the mail recently between Providence and Block Island, R. I., might easily have been mistaken for a steamer using soft coal, only I never saw a steamer emitting such a quantity of black smoke continuously. I do not know what the percentage of carbon monoxide might be; but the uncombined carbon was visible at a distance of three or four miles, and probably there was CO mixed with it.

The public demands an engine that is stable while idling and that will accelerate without hesitation. That condition can be obtained in a gasoline engine only by having an excess of fuel in the mixture. It may not be possible to run an Otto-cycle engine with an exhaust showing as low a percentage of CO as will be found in that of a Diesel engine, but the Bureau of Standards' records show successful operation of an Otto-cycle engine on the test stand with a fuel consumption of less than 0.40 lb. per hp-hr. That involves an exceedingly high air-efficiency for an engine having the compression ratio which that engine had. Very little carbon monoxide can be left in a mixture burning as efficiently as that in an Otto-cycle engine.

Virtually all Diesel auxiliary engines on motor yachts smoke, which indicates uncombined carbon but not necessarily carbon monoxide.

J. M. ROYAL[3]:—A surplus of air is fundamental in the operation of a Diesel engine, and that surplus is unfavorable to the production of carbon monoxide. The Otto-cycle engine is theoretically limited to the use of a nearly perfect mixture, so that conditions cannot be so nearly ideal for complete combustion in the ordinary gas engine as in the Diesel type.

Catalytic action is one of several possible methods for producing more nearly complete combustion. This may be accomplished by some catalyst that will be a part of the fuel, or by the surfaces upon which the combustion takes place. Injection of water with the air used to be common in semi-Diesel engines, and that had a very beneficial effect upon the combustion. Such a medium might be injected with the oil. It is known that oils suitable for Diesel fuel will mix with water at extremely high pressures and the mixture will remain fairly stable after the pressure is reduced. Such mixtures are effective in increasing both the rate and the completeness of combustion.

[2] M.S.A.E.—Engineer, Bensenville, Ill.

[3] Mechanical engineer, Western Electric Co., Chicago.

Superchargers and Supercharging

Discussion of Oscar W. Schey's 19th National Aeronautic Meeting Paper[1]

VARIOUS FEATURES of the paper are commented upon by one discusser, who points out that an infinite number of superchargers of each type is assumed, each supercharger operating only at its critical altitude. Altitude-laboratory tests of the Roots supercharger designed for a particular altitude are said to give nearly constant brake-horsepower from sea level to the critical altitude. Advantageous features of geared centrifugal superchargers are stated, and comments are made on the performance of a turbo supercharger at altitudes above the critical altitude. Simplicity and reliability are said to be the reasons why the centrifugal supercharger is selected in preference to the two other types.

Constructive criticism is presented by another discusser regarding fuel consumption and head resistance, and these are commented upon. In conclusion, it is stated that very few of the non-military aircraft-engine types are yet provided with superchargers, but it is evident that the Department of Commerce must ascertain the ability of such engines to withstand full-throttle operation at sea level and must seriously consider the efficacy of "throttle-stops" which the pilot can disregard at will.

H. K. CUMMINGS[2]:—We at the Bureau of Standards read this paper with great interest. The first part is in line with experimental work that the Bureau has been conducting for the last five years, and this checks with the results presented to a very satisfactory degree. For instance, in Fig. 4, the gross brake-horsepower to be expected at different altitudes is entirely in line with the Bureau's figures, and the figures for the net brake-horsepower of the geared centrifugal supercharger are in excellent agreement. As in the case of Fig. 3, I assume this curve to be based on 100-per cent efficiency of the supercharger. Applying the same criterion to the Roots-supercharger results, we judge that the curve is somewhat unfavorable to the Roots type because, for an altitude of 36,000 ft., our figures give 75 per cent instead of 70 per cent of the initial 100 per cent.

Without careful reading of the text, the method of representing these results might lead to erroneous conclusions; but, as the author has explained correctly, an infinite number of superchargers of each type is assumed, each supercharger operating only at its critical altitude. The unsupercharged curve is presumably computed according to the formula

$$(Hp.)_2/100 = [P_2/29.92]^{1.15} \cdot [T_2/518]^{-0.5}$$

which is a somewhat empirical expression for the variation of brake horsepower with temperature and pressure and does not hold any too well over a great range. The Bureau's experimental results with brake horsepower on various engines give in general slightly lower figures. The brake horsepower at altitude depends on mechanical efficiency as well as on temperature and pressure.

In Fig. 5 the case of an actual Roots supercharger with rated altitude of 20,000 ft. is considered, and the power is shown as falling off from a value approaching 100 b.hp. to 93 b.hp. at the rated altitude. The Bureau's altitude-laboratory tests indicate that the Roots supercharger designed for a particular altitude gives nearly constant brake-horsepower from sea level to the critical altitude. From values obtained in preliminary tests with a Roots supercharger designed to have a critical altitude of 20,000 ft., a value of 96 b.hp. is suggested as approximately correct from sea level to 20,000 ft. If the carbureter pressure is kept at 29.92 in. of mercury, only about 2 b.hp. would be gained by using a gearshift and operating the Roots supercharger at reduced speed below 10,000 ft.

In practice, the gear-driven centrifugal superchargers are mainly used between the carbureter and the engine. In that case one is practically forced to the throttling method of taking care of the extra capacity below the critical altitude. I believe it is not essential that the throttling method be used if the centrifugal supercharger be located in front of the carbureter, as in the case of the Roots type. It would be interesting to know whether either Mr. Schey or Mr. Moss has comparative figures on the performance of the gear-driven centrifugal supercharger in the two positions. Another point on which it would be interesting to have information concerns the weight and bulk of the intercoolers required to meet the condition which has been arbitrarily set up in basing the theoretical curves on 59 deg. fahr. at the carbureter entrance when these superchargers have an experimental exponent of compression of 1.6.

OSCAR W. SCHEY:—It is true, as Mr. Cummings says, that in practice we are forced to employ the throttling method for controlling the geared centrifugal supercharger, because the supercharger is located between the carbureter and the engine. I am of the opinion, however, that it is necessary to employ the throttling method of control on a single-stage centrifugal supercharger unless a gearshift is used, regardless of the location of the supercharger with respect to the carbureter. Controlling the quantity of air delivered to the engine by bypassing is less satisfactory than the present throttling method. Bypassing the compressed air would not result in a saving in power, because

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[1]The paper was published in the May, 1931, issue of the S. A. E. JOURNAL, beginning on p. 524. The author is an associate mechanical engineer of the National Advisory Committee for Aeronautics, City of Washington. A brief abstract of the discussion is printed herewith.

[2]S.M.S.A.E.—Chief of automotive powerplant section, United States Bureau of Standards, Department of Commerce, City of Washington.

the power is absorbed by the high-speed impeller in increasing the velocity of the air before the air is bypassed.

Geared Centrifugal Superchargers

SANFORD A. MOSS[3]:—The curves given in the paper for a geared centrifugal supercharger arranged to give sea-level pressure at a given altitude are constructed on the basis that exactly sea-level pressure is maintained in the inlet manifold at lower altitudes, giving the loss by throttling which is mentioned; however, this theoretical diminution in engine power never occurs in practice. The mere fact that throttling is necessary to give sea-level pressure in the inlet manifold means that the supercharger itself has a considerable amount of reserve. In actual flying, pilots always use some of this reserve. Instead of closing the throttle so as to maintain the theoretical sea-level pressure assumed for the curves, they close the throttle a slightly less amount so that there is a pressure in the inlet manifold somewhat above that at sea-level, which enables the engine to deliver full rated power to the propeller. To obtain the full rated power as the net power of the engine in this way, it is of course true that the gross power of the engine, including the power required to drive the supercharger, is slightly more than the rated power of the engine at the critical altitude. Hence the engine actually operates with a gross power which gives a slight overload; but no modern aircraft engine will fall apart on account of this slight amount of power excess, and no decrease of time between overhauls has been observed that can be ascribed to it.

There is also a theoretical effect on fuel economy. To take account of the slight increase in compression pressure which ensues, the facts that the friction power of the engine itself is not increased and that the scavenging of the clearance space due to the pressure above that at sea level in the inlet manifold would impose a very difficult theoretical problem. Experience indicates that fuel economy is affected but slightly and is improved if anything. One of the problems which the National Advisory Committee for Aeronautics may take up in the future is the investigation of fuel economy of an engine having a geared centrifugal supercharger which maintains the net power constant at all altitudes up to the critical altitude, as is usual in actual operating practice. As mentioned, this operation is to be distinguished from operation with constant pressure in the inlet manifold, which is the basis of the theoretical curves in the paper. Such operation with constant net engine power means that at low altitudes a geared centrifugal supercharger still gives the engine a power reserve which can be used during take-off or emergencies. The pilot must not use all of this power reserve except in emergencies; otherwise, the engine would be unduly overloaded.

An engine with a geared centrifugal supercharger designed to give sea-level power at a given critical altitude is to be compared with an unsupercharged engine with displacement large enough to deliver the same power at the same altitude. The loss due to throttling to reduce the power at sea level to the same value as at the given altitude is practically the same in either case. Of course, the engine that is equipped with the geared centrifugal supercharger is a very much lighter engine than the equivalent unsupercharged engine would be.

The reserve power below the critical altitude already mentioned also exists with a turbo supercharger, and the pilot can easily adjust the amount of supercharging so as to give whatever "boost" of power, above the sea-level power of the unsupercharged engine, is considered safe for the engine. Such a boost is regularly used in the actual operation of turbo superchargers.

Performance Above the Critical Altitude

As to occurrences with a turbo supercharger at altitudes above the critical altitude, little information is available either in the paper or elsewhere. A great quantity of flight data makes it certain that enough power is delivered by the engine to give successive increase of propeller speed with a constant propeller as higher altitudes are reached. Data also exist making it certain that the number of revolutions per minute of the supercharger itself increases appreciably as successively higher altitudes are reached. Actual pressure-measurements at high altitude exist showing that a turbo supercharger rated at about 24,000 r.p.m. certainly reaches a speed of between 32,000 and 35,000 r.p.m. at high altitudes.

At these high altitudes, the amount of exhaust gas delivered by the engine increases on account of the increased engine speed, and the amount of power from this exhaust gas increases greatly due to the decrease of the discharge pressure at the nozzle, which corresponds to the pressure at the given altitude. A complete theory of all these occurrences has never been worked out, but it is believed that a turbo supercharger will show power at high altitutes greater than that indicated by Fig. 5 of the paper.

For the case of an engine purposely designed to withstand so-called "boosting" at sea level, as is now becoming customary, the curves in the latter part of the paper are very illuminating. The investigations show that brake mean effective pressures of over 200 lb. per sq. in. can be maintained without difficulty by use of a sufficient amount of supercharging. Most engine builders are steadily increasing this boosting or supercharging at sea level, and the advantages given in the paper indicate that this tendency is bound to continue.

Centrifugal Supercharger Said To Be Preferable

CHAIRMAN ARTHUR NUTT[4]:—The centrifugal supercharger is selected in preference to the other two types on account of its simplicity and reliability. The exhaust-driven type necessitates an excessive amount of plumbing on the engine, increases frontal area and is more inaccessible. At the critical altitude—or above this altitude, particularly—if a pilot throttles the engine the turbine slows down and, before the turbine wheel gets back to normal speed, the supercharging pressure has dropped and the airplane must fall out of formation. This point must be given serious consideration before this type of supercharger can compete with the centrifugal type. We have built engines equipped with superchargers of both the Roots and the centrifugal types with the same engine weight, on the same

[3]Thomson Research Laboratory, General Electric Co., West Lynn, Mass.

[4]M.S.A.E.—Vice-president of engineering, Wright Aeronautical Corp., Paterson, N. J.

engine model. I believe that the mechanical difficulties of driving the Roots-type supercharger are greater than they are with the centrifugal type, and that the Roots type is more expensive as well as more noisy.

Constructive Criticism Offered

J. H. GEISSE[5]:—The paper is misleading in a number of points. The curves shown indicate that there was very little effect on the specific fuel-consumption in supercharging; in fact, Mr. Schey got a slightly lower specific fuel-consumption with the engine supercharged. But that does not take into consideration in any way whatever the character of the fuel that must be used. I think that if the specific fuel-consumption which one could get with various supercharging pressures and various compression ratios which would just allow the fuel to be free of detonation were plotted, one would find that there is a considerable sacrifice in fuel consumption by supercharging. That is shown definitely in some of Mr. Schey's curves, if they are given very careful consideration.

The other point that Mr. Schey brought out was that he could increase the power of the engine very materially without apparently increasing the head resistance with the same size of engine. That is not true and is shown to be untrue by his other curves, which indicate a very considerable increase in jacket loss. If one has only sufficient radiation for the normal unsupercharged engine, it is manifest that one must increase the size of the radiator when the supercharger is added and that the head resistance is thereby increased.

The curves also show that, if one considers the increase in compression ratio which one would use if one did not supercharge and its effect on decreasing the jacket loss, the results are not exactly as they were pointed out. Mr. Schey said that the power was increased without increasing the resistance appreciably by supercharging; but the curves show that there is a higher jacket-loss for any given compression ratio. If, in addition to that, consideration is given to fuel limitations, the lower the supercharge pressure is, the higher is the compression ratio one can use; and one can decrease the size of the radiator instead of increasing it.

MR. SCHEY:—Regarding the loss to the cooling water and how much it would increase the size of radiator, we found that, at a compression ratio of 7.5:1 with sufficient boost to increase the power 50 per cent, the loss to the cooling water was increased 34 per cent, and that at a compression ratio of 3.5:1 and a boost to give 50-per cent increase in power, the loss to the cooling water was increased 20 per cent. The percentage increase in power is much greater than the percentage increase in radiator area. It is true, as Mr. Geisse says, that I did not mention this in connection with head resistance; however, well-designed radiators have a small resistance, particularly on racing planes.

MR. GEISSE:—Mr. Schey showed a 32-per cent increase in radiator requirement by supercharging at a compression ratio of 7.2. To supercharge at a 7.2 ratio he had to use a much better fuel than when the engine was not supercharged.

MR. SCHEY:—We also use gasoline. We could not increase the compression ratio as high with gasoline as we could with benzol, but we did supercharge the low-compression engine up to a pressure equivalent to 10 in. of mercury and there was no effect; in fact, the fuel consumption was the same.

MR. GEISSE:—The fuel consumption might have been the same for a 3.5 compression ratio; but it was not as good at 3.5 as it is for a 5.1 ratio, which could have been used.

MR. SCHEY:—It was the same for the 5.1 ratio up to a pressure equivalent to 3.5 in. of mercury.

MR. GEISSE:—It was not the same as for the 3.5 ratio.

MR. SCHEY:—No, the curves show that. We all agree that the fuel consumption of an engine decreases considerably with increase in the compression ratio. What we wish to stress in these tests is that the power increases with boosting much more than the losses to the cooling water increase; that a large increase in power can be obtained with a comparatively small increase in maximum cylinder-pressures; and that it is advisable to supercharge an engine of highest practicable compression-ratio because the power increase will be greater, the exhaust-gas temperatures will be lower, and the power required by the supercharger to maintain the same pressure at the carbureter will be less.

CHAIRMAN NUTT:—We have checked Mr. Schey's figures quite closely on the Super-Conqueror engine by getting 50-per cent increase in power with about 34 per cent more radiation, which is far from being equivalent to 34 per cent more head-resistance. It is only 34 per cent on the radiator, which represents a very small proportion of the head resistance of the engine.

DR. H. C. DICKINSON[6]:—Are the curves giving the increase in maximum cylinder-pressure with increase in compression ratio experimental curves?

MR. SCHEY:—These curves of maximum cylinder-pressures were experimentally determined.

DR. DICKINSON:—That does not seem to check with other experimental data on the same subject, because the maximum cylinder-pressure does not rise very much with a compression ratio above a ratio of about 7:1. It rises fairly well up to 7:1; but above that ratio, due to various factors, the maximum cylinder-pressures at a compression ratio up to 14:1 are hardly appreciably higher than they are for a ratio of 7:1. So the disadvantage of a high compression-ratio is not so great as it seems to be. I think a compression ratio of 15:1 would give maximum pressures only comparatively little higher than would a 7:1 ratio.

QUESTION:—Why, at the high compression-ratio, did not the exhaust temperature increase with the boost as shown in Fig. 21?

MR. SCHEY:—Boosting the carbureter pressure 10 in. of mercury at a 7.5:1 compression ratio results in an increase of 10 deg. fahr. in exhaust-gas temperature, and boosting the carbureter pressure 10 in. of mercury at a compression ratio of 3.5:1 results in an increase in exhaust-gas temperature of 75 deg. fahr. As care was exercised in installing and calibrating the thermocouple, we are satisfied that the readings are correct. The small increase in exhaust-gas temperature at high compression-ratios is believed to be due to the small percentage of residuals present.

QUESTION:—How was the brake horsepower determined?

MR. SCHEY:—A calibrated propeller was used.

MR. CUMMINGS:—Mr. Schey states that super-

(*Concluded on p.* 84)

[5]M.S.A.E.—Vice-president of engineering, Comet Engine Corp., Madison, Wis.

[6]M.S.A.E.—Chief of the heat and power division, United States Bureau of Standards, Department of Commerce, City of Washington.

Commercial Flight-Testing

Discussion of Lieut-Com. E. W. Rounds' 19th National Aeronautic Meeting Paper[1]

DETERMINATION of landing speed is the topic receiving the greatest attention. Methods discussed include the suspended bomb, photographic and mechanical, one discusser describing in some detail the photographic method used in Germany.

Other topics covered include the effect of change of weight upon airplane performance, stability testing and air-speed-indicator calibration. One discusser who was in the Army during the World War and for a short time thereafter spoke of his experiences in connection with the pioneer development of instruments for performance tests.

CHAIRMAN T. P. WRIGHT[2]:—In determining the relation of stalling speed and landing speed to each other and the lowest possible speed of an airplane, is the suspended-bomb tube method the only one that can be safely used or can some other method be used? This point is extremely interesting to me because I think that the landing speed of airplanes is probably the most misrepresented in advertising of any of the characteristics.

LIEUT-COM. E. W. ROUNDS, U.S.N.R.:—The most accurate method of determining low speed and landing speed is by the use of the suspended bomb, but by the intelligent use of a carefully calibrated air-speed indicator, the landing speed can be obtained within less than 1 m.p.h. I would hesitate to say that any airplane lands at a certain speed and expect the figure to be accurate within less than ½ or ¾ m.p.h. unless the suspended-bomb or some equivalent method is used. For most practical purposes, going to the trouble of the suspended-bomb method is unnecessary.

Determining landing speed by reading the air-speed indicator at the instant of touching the ground is not always feasible, particularly in some single-seaters where the pilot is occupied with landing rather than watching the indicator. For altitudes of not over 3000 or 4000 ft., the difference between the minimum gliding-speed and the stalling speed would be negligible, provided we have sufficient longitudinal control to hold the plane at the angle of maximum lift.

Determining Landing Speeds

E. P. WARNER[3]:—For a long time, the absence of any commercial or governmental organization that is equipped and prepared to undertake the testing of commercial airplanes and the measurement and certification of their performance has been felt. We have not been satisfied with any of the alternatives that have so far been proposed, and I am sure that anyone who studies performance data as they are spread broadcast and attempts to interpret them in terms of what we know about aerodynamics and performance prediction and the application of performance formulas will come to the conclusion that the situation is very unfortunate.

I have undertaken to measure landing speeds from time to time by photographic methods, in which we eliminate the necessary clearance between the airplane and the ground, and my unusual experience has been that the difference between the actual landing-speed and the minimum flight-speed is between 2 and 5 m.p.h., due to ground effect and also to the fact that when a pilot goes out to make a landing-speed record he does not commonly conform to the specifications laid down by Commander Rounds of having the path of the airplane tangent to the surface of the earth at the instant of contact. He is much more likely to land about 8 ft. high or as far above that point as he thinks the landing gear of the airplane will permit and to lose some more speed while dropping vertically. I have always supposed the ground effect was a very definite reality, especially on low-wing monoplanes and to a somewhat less extent on biplanes.

Incidentally I must also pay due respect to the optimism shown by Commander Rounds in saying that getting the landing speed within 1 m.p.h. is close enough. To get it within 10 m.p.h. would be a decided advance over some present practice. Pilots, who were perfectly honest in their statements, have given me the landing speed for a certain airplane all the way from 50 to over 70 m.p.h. Only a few pilots, after all, have had very extensive experience in test work. Any good transport pilot can be taught enough about testing in a relatively short time to enable him to make maximum-speed and climb tests if he takes the specifications that are laid down here and learns them by heart and follows them. I am afraid that imparting the peculiar flair for watching everything at the same time which Commander Rounds and a few others possess will take much longer. I know many pilots who have really tried to keep an eye on the air-speed meter or to be conscious of what the air-speed meter is doing up to the instant of contact with the ground, and have secured widely varying results, because the air-speed meter is a very subordinate consideration at the time of landing, and the tendency is, without any conscious intent, to read it after the machine is safely on the ground and has rolled some distance. Photographic methods are, of course, available and can be applied with a great measure of reliability.

Tests made in New York City several years ago under my own supervision and others recently made at Leland Stanford have shown that the landing speed of the same airplane with the same pilot can be checked repeatedly

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[1] The paper was published in the May, 1931, issue of the S.A.E. JOURNAL, p. 511. The author is a Member of the Society and is an aeronautic engineer at the Naval Air Station, Anacostia, D. C.

[2] M.S.A.E.—Vice-president and chief engineer, Curtiss Aeroplane & Motor Co., Garden City, N. Y.

[3] M.S.A.E.—Editor, *Aviation*, New York City.

within 1 m.p.h., with a somewhat larger deviation due to the difference between pilots. Landing speed is defined in the paper as

> . . . the minimum sea-level speed at which a normal landing can be made. For seaplanes this speed has no dependence upon the attitude of the plane when at rest on the water, but for land planes it is the speed at which the airplane makes a three-point landing with minimum vertical velocity.

That is usually the case on a well-designed plane but need not be a limitation on the definition. I see no fundamental objection, if the designer has given the airplane a ground angle of 4 deg. to permit the pilot to land wheel high, in making a one-point landing and losing some speed by taking part of the load on the tail-skid before the wheel has struck the ground. I am not sure that I am prepared to write a complete definition of landing speed in that case, but I am very clear in my own mind that where the landing angle has been made abnormally large for some reason, usually to secure air-braking and to decrease the length of run, the landing speed should be taken as the speed at the time the airplane touches the ground even though the contact is two point, and even though when the tail-skid drags on the ground, the angle of attack will be larger than the angle of maximum lift.

I am inclined to question the specification that the calibration of an air-speed meter on the speed course should be made with a gross load not differing more than 15 per cent from that carried in tests. Certainly, that specification is good as far as it goes, but does it go far enough? Commander Rounds gives an arbitrary figure that is probably correct if the air-speed meter is installed with enough care and is placed well ahead of the leading edge, but getting the air-speed meter out very far ahead is not always very convenient and my own experience in making these calibration runs has been that the curves sometimes have a pronounced hook at the lower end. Of course, the curve is a function of two things, the error in the instrument and the attitude of the airplane, and where sudden irregularities appear, the attitude of the airplane commonly will account for them. A 15-per cent change in gross load may mean a change in the angle of attack of as much as 2 deg. up near the upper end of the lift curve, and that is a very pronounced alteration in the angle at which the air actually meets the pitot tube. It is still worse if a venturi is used.

Effect of Change in Weight

On the high-performance airplane, which I assume was a pursuit machine with a speed range of 57 to 158 m.p.h., the initial climb is shown to have been improved 6.5 per cent by a reduction in weight of 8.9 per cent according to Table 1. I have been trying to figure out any possible way in which a reduction of weight could increase the horsepower required or decrease the power available. I do not see, offhand, why it should affect the horsepower available at all or increase the horsepower required, except at very high speeds of flight, far beyond the climbing range. So I cannot see how the power available for climbing could be decreased. If anything, it would be increased, and therefore I should think that in every case the change of climb would be at least inversely proportional, or would be rather more than inversely proportional, to the change of weight, and the percentage change would have to be at least as much as the 8.9-per cent. decrease in weight. Can Commander Rounds offer any theoretical explanation for that, or have I overlooked anything in my hasty consideration of the subject?

LIEUTENANT-COMMANDER ROUNDS:—The figures as given in Table 1 are the results of tests that we made. In this high-performance airplane, which has had a decrease in weight of 8.9 per cent, the initial rate of climb was increased 6½ per cent. I have not tried to reach any real relation between the figures and have offered them merely as the results of the tests we made.

MR. WARNER:—I was just reckoning that the excess horsepower for climb, when you decrease the weight, would be at least as large as before. Therefore,

$$P_e/W_1 = R_1$$

and

$$P_e/W_2 = R_2$$

and, therefore, at least in the worst case,

$$R_1/R_2 = W_2/W_1$$

LIEUTENANT-COMMANDER ROUNDS:—I do not know why a variation from theoretical figures should occur on this basis. Probably it results from not being able to determine the performance accurately enough.

CHAIRMAN WRIGHT:—As I get Mr. Warner's point, the weight limits during the test should vary less than 15 per cent.

MR. WARNER:—That is another point.

LIEUTENANT-COMMANDER ROUNDS:—Of course, another factor has entered into this particular test. When the airplane was first tested with the original weight, a complete set of performance tests were run through that way and the tests with the reduced loading were made some time later.

I am not prepared to say how much difference in performance we will get in service. In some airplanes the difference has been considerable and in others we have not been able to detect any difference. Possibly the airplane had deteriorated since the first tests had been run.

MR. WARNER:—The maximum-speed results seem to be almost what would be expected in both cases.

LIEUTENANT-COMMANDER ROUNDS:—In fact, the figures on the maximum speed differ between 0.1 and 0.2 miles, a difference in speed that I thought was not worth considering. All I can suggest is that possibly the performance of the airplane decreased between the dates of the two tests which could not be run accurately enough to detect that rather small difference shown in the proportionate changes.

This definition of a normal landing is one that we assume in giving the results of our test and was intended to apply more to my paper than to anything else. We have had airplanes which, when they were at rest on the ground, had an angle of attack that was so much less than the angle for maximum lift that, to make a minimum-speed landing, they had to land tail first, which does not seem to be a desirable thing to do. For this reason, that definition, as far as I was concerned, applied more to my interpretation of a normal landing.

Air-Speed-Indicator Calibration

In only 1 or 2 cases out of 100 or more have we found an air-speed-indicator calibration-curve with a pronounced hook at the lower end, and in many instances the calibration curve has been almost a straight line, down to speeds that certainly include 5 m.p.h.

above the landing speed. Now we calibrate the air-speed indicator at low speeds by flying in formation with another airplane that has a considerably lower minimum-speed, which permits us to get a point at the indicated landing-speed, and the results are fairly reliable. On one occasion when a certain plane did not meet a contract guarantee, we made seven or eight independent determinations of the calibration curve in the region of indicated landing-speed, and it showed no tendency to be anything but a straight line at those lower speeds.

Recently we had a seaplane, the landing speed of which was in question, and we had to repeat the calibration. In addition to making two sets of runs in the air, the pilot also made a run on the step at about 2 m.p.h. less than his indicated landing-speed, and the result gave a point that was 2 m.p.h. lower in the indicated speed than the calibration curve. In other words, for a given air-speed-indicator reading, the point that he obtained by running on the step and at an angle of attack considerably less than that of maximum lift gave a higher true speed.

Giving landing speeds to within 1 m.p.h. is justified by the results we have obtained. I was inclined to give higher accuracy, but decided that probably I might be stretching it a little. We had occasion some time ago to measure minimum speeds of 35 to 40 m.p.h., and thought we were getting within about 0.3-m.p.h. accuracy.

We have found no evidence to indicate that any relation between landing speed and minimum gliding-speed and the ground effect exists in most of our service airplanes. In this I assume sufficient longitudinal control, which has been lacking in some planes. The results indicate an identical indicated-speed, both for stalling speed up to 3000 or 4000 ft. and what I have defined as a normal landing where we can reach the maximum angle of attack or rather the angle of maximum lift.

MR. WARNER:—Most of our supposed ground effect then actually must be due to the pancaking of the plane and the killing of speed during the last few feet of fall by a pilot who is usually the manufacturer's employe and is trying to make the lowest landing-speed he can for record purposes.

LIEUTENANT-COMMANDER ROUNDS:—Probably that is the case. Very often we see a landing made with considerable vertical velocity. The type of landing I am speaking of is one that has the minimum vertical velocity.

Stability Testing

So far we have not found any quantitative methods of full-flight stability testing that have amounted to anything. We have also found airplanes that have been the subject of considerable discussion as to what their characteristics really were. Various pilots think differently about the same thing. Longitudinal stability can be determined under at least two conditions, one of which is with fixed controls and the other with free controls.

Usually we consider that the airplane will be more stable dynamically with fixed controls than with free controls, but we have lately encountered an airplane that was not. With fixed controls this plane was less stable than with free controls. Apparently this was due to the peculiar effect of the balance on the elevator.

In obtaining longitudinal stability about the transverse axis with either fixed or free controls, we try to balance the plane with the adjustable stabilizer. Then we disturb the plane, and return the fixed controls to the same position as they had in the state of balance. With free controls, we bring them back to that position, then release them and also free them when the plane has been disturbed. We try to cover all conditions and observe what the airplane does. We consider that an airplane is longitudinally stable, if, after a series or one or less than one oscillation, it resumes somewhere near the speed and altitude of the condition before it was disturbed. Some planes are so near the borderline that very slight bumpy air is enough to throw the determination out and about all we can say is that they are nearly neutral.

If, when an airplane is flying straight ahead and level and the rudder is moved so that the plane assumes an angle of yaw, the plane then tends to bank in the proper direction or to turn in the proper direction, it at least is not very badly unstable about the fore-and-aft axis. That banking might be due to increased speed of the outer wing, and we then test the airplane in a side slip, trying to maintain a constant angle of yaw. If the wing tends to rise, we take that as evidence of lateral stability. I believe all airplanes should be laterally stable, so that if the aileron controls are broken, the plane can be landed without rolling onto its back.

For directional stability about the vertical axis we depend more on our opinions than anything else. If we move the rudder and the plane tends to maintain an angle of yaw, it probably is not directionally stable with free control. A tendency to decrease the angle of yaw, after the plane has been displaced, is an evidence of directional stability. A plane might be directionally unstable with the rudder held in neutral but still be controllable due to the increased lift in the tail surfaces with rudder deflection. If the plane is unstable directionally, it usually handles badly in a turn and tends to skid and in general feel disagreeable. If the plane is laterally unstable, it does not necessarily exhibit that same characteristic, but a plane that tends to skid around on the curves is usually one that is insufficiently stable directionally.

S. E. LEA[4]:—Can standards for directional stability be established and a factor set? The human element enters and we use our opinions to such an extent that it seems almost impossible.

LIEUTENANT-COMMANDER ROUNDS:—No doubt should arise as to whether an airplane is stable or not, but often a doubt exists as to whether it is neutral, slightly stable or slightly unstable. When we do not have very much on which to base our conclusions, two people will very often come to different conclusions; also, if people do not know exactly what they are doing, they are likely to come to incorrect conclusions.

Photographic Measurement of Speeds

R. M. MOCK[5]:—The photographic method of measuring landing speed that Mr. Warner mentioned is standard in Germany and I believe in Holland also, and the same method is often used for measuring high speed. A special camera that is mounted on a tripod and directed at the airplane is used. The path of flight is usually along the line connecting the airplane and the camera, either toward or away from the latter. This line is

[4] A.S.A.E.—Aircraft mechanic, Keystone Aircraft Corp., Bristol, Pa.

[5] Jun. S.A.E.—Consulting engineer on design and production, Ernst Heinkel Flugzeugwerk, Warnemunde, Germany.

chosen in the direction of the wind. The camera has two lenses, one of which is focused on the airplane and is usually a fixed focus for distance, while the other is focused on a stop-watch that is started before the test photos are made. As the airplane flies toward the camera, in one picture we record the photograph of the airplane and, knowing the distance between two stripes painted on the wing or the actual distance between the wing struts and the focal length of the camera, we can calculate how far the airplane is from the camera. From the next picture we can calculate the elapsed time between exposures from the two successive stop-watch pictures and how far the airplane has traveled in that time from the calculation of the distance between the airplane and the camera. Thus, we have the rate of speed of the airplane between successive pictures and can calculate the change in speed in the interval.

In Germany the D.V.L., the government bureau that corresponds with the Department of Commerce in this Country, has developed an instrument which is contained in a compact box. It is set on a tripod at one end of the field, and the airplane flies over the camera, which takes one picture for every turn of a crank. The airplane flies at various predetermined engine-speeds and possibly makes two or three landings. When the inspector is through he has the whole story on the film. High speeds measured photographically check almost exactly with those measured in the usual way.

Usually, for factory flight tests, the factory where I was in Germany did not make the speed test over a course on the ground between two points alone, because of the inaccuracy of the side wind, which would veer over the whole compass from day to day. Usually, we could not wait until the wind was in the direction of a two-point speed course, so we used two courses that were practically at right angles to each other and measured the speed on both. In calculating the air speed, the two courses were drawn on a map with the same angle between them as in the geographical layout, their lines being extended to make a cross on the paper. The measured ground-speeds were laid out on each arm of the cross away from the center, by scaling the ground speed on the arms corresponding to the direction of the flight. This gave four points, each a distance away from the center corresponding to the ground speed in that direction. If the four ground-speed measurements were accurate, a circle could be passed through those four points. Assuming that all four points laid on the circle, the center would be away from the intersection of the two lines of the cross and the distance to that intersection would be the wind velocity and would give the direction of the wind. Usually a slight variation due to the human element in timing was found, but all four results could be averaged and a very close observation of the air speed obtained. If an error was made in one of the ground-speed measurements, the circle would not pass through all four points and the error would be noticed.

LIEUTENANT-COMMANDER ROUNDS:—That is certainly very interesting. I am certain you could not conceive a more scientific way of measuring speed.

CHAIRMAN WRIGHT:—Does Commander Rounds feel that eventually the standard flight-testing will be performed by the photographic method for all characteristics to eliminate the human element entirely? That might be more readily possible if a standards bureau could do the testing.

LIEUTENANT-COMMANDER ROUNDS:—An attempt to make some flying tests and speed tests at altitude by the triangulation method is already under way. I do not know what the results will be.

Judging from the experience we had in trying to measure wind velocity under certain conditions, I wonder whether the photographic method that was described is really justified. During a run of about 100 ft. we found that with certain planes the wind velocity would vary 4 or 5 m.p.h. under conditions that presumably were nearly constant. Two people with separate anemometers, standing 100 ft. apart, would also find differences of 3 or 4 m.p.h. in their determination of the wind.

MR. MOCK:—That also affects the high-speed measurements in flying over speed courses in the same way.

LIEUTENANT-COMMANDER ROUNDS:—By the time we make several round trips with figures that check, we can be reasonably sure that the wind has been taken care of. Of course, we do not ignore high winds.

MR. MOCK:—You have the same way of measuring the side winds as measuring the wind in the landing-speed measurements.

LIEUTENANT-COMMANDER ROUNDS:—One way of overcoming the difficulty, which is common practice, is letting the plane drift.

MR. WARNER:—Other photographic methods are available. We all have enormous admiration for the German work, but I am somewhat startled at this proposition of flying a plane into a camera and looking at the size of the image on the photographic film as a basis for speed calculation.

MR. MOCK:—These pictures are usually enlarged in about the same ratio as a lantern slide is enlarged for projection before the measurements are made.

MR. WARNER:—Certainly that can be done, but it requires extraordinary nicety of technique and extraordinarily fine photographic apparatus. Landing speeds can be measured much more simply with sufficient accuracy so that the error due to the wind is the large residual error. That might not be over 1 m.p.h. with gentle winds.

With a very much simpler apparatus and a simpler method, either with a second pendulum beating in front of the camera or with simply the interception of the image in front of the camera at known intervals of 10 or 15 sec. timed by a stop-watch during the camera runs, the speed of the camera is nearly constant enough so that the exposures can be made and uniformly spaced. Then we can photograph at right angles to the direction of the travel with the airplane, the camera being in a fixed position on the ground. The length of the airplane shows the scale in the picture and its rate of motion between exposures can be determined by projecting on the screen and measuring the airplane's movement in terms of its own length with very great nicety and extreme simplicity, both of taking the pictures and working up the results. This method is not very dissimilar from that used at Leland Stanford, Jr., University, and I think it would quickly occur to anybody casting about for a cheap way of using ordinary cheap photographic apparatus with a lens that perhaps is not of the highest grade.

We can go farther than that with photographic apparatus in getting the human element out of the flight test. Much has been done by the National Advisory Committee for Aeronautics on apparatus for service testing, but it takes time to install, much work being

required on the airplane before starting the measurements. As far as we can, we ought to get entirely outside of the airplane and work with an apparatus that can be installed on the ground except for measuring control movement. That we must do inside the cockpit.

Another illustration of the use of the photographic method in an unusual problem, where the human element has been considered dominant, is the problem we had some years ago of measuring the maneuverability of certain commercial planes to be used on a mail run, where the pilot's most common problem was to pull suddenly out of a valley or off the level when he saw obstructions rising directly ahead. We laid down specifications for certain types of maneuver involving only one axis and photographed the actual path in the sky and its radius of curvature. The length of time required to incline the path upward in response to a sudden pull-up, or to gain height when the throttle was suddenly pulled open, could be determined.

We can do considerably more in the introduction of the relatively simple and inexpensive mechanical methods in performance testing than has been done as yet. This will be necessary, because the Army and Navy have been able to depend on test pilots of unusual skill, but when we get a number of manufacturers who are honestly trying to determine performance for themselves as accurately as possible with their own pilots, we must establish a technique where the pilot has nothing to do except fly the airplane and the records are made with as little intervention from him as may be.

LIEUTENANT-COMMANDER ROUNDS:—Too much emphasis is being placed on the personal equation. No matter how good a test pilot may be, he cannot in any way overcome the atmospheric conditions, which to my mind constitute the biggest variable factor in performance testing. Any good pilot can be taught, without any great difficulty, how to actually fly the plane to get the best results out of it, provided someone who is experienced will supervise his work and he is willing to follow the directions of this supervisor.

The variation in performance is very much greater than the errors due to taking incorrect data or failing to check very small speed-variations. What we get in our performance testing is not really the actual results of a particular climb-test, but a mean result of a number of climbs. This we try to interpret into representative performance for the airplane, and we have to determine what results can be taken as reliable and what have to be ignored.

The personal equation is not the big factor now; the method of interpretation of results is really the primary factor.

W. F. GERHARDT[6]:—At this time selecting the proper type of instruments for present use and future development is important. The main question is, shall they be in the airplane or on the ground?

The National Advisory Committee for Aeronautics has demonstrated that a high degree of accuracy can be attained if sufficient time and personnel are available. At least one central bureau, such as suggested by Commander Rounds, should be established to take care of exhaustive tests. However, in the present development stage of aviation the need will probably arise for methods that can be used locally by any engineering test pilot. For this purpose the use of small compact instruments in the airplane, utilizing smoked drum records wherever possible, is most desirable, as these give records with fine lines from which data, such as path tangents, can be obtained directly and the sheet can be conveniently filed for future reference.

Photographic-film methods should be avoided as much as possible. In the case of the accelerometer, which is essential in measuring dynamic loads and maneuverability, such as mentioned by Mr. Warner, the use of film is apparently unavoidable. Motion-picture-camera records taken from the outside have, however, the disadvantage of requiring more interpretation and calculation than the records of instruments in the airplane. The development of a practical instrument to be carried in the airplane for take-off and landing tests is not impossible.

What, in Commander Rounds' opinion, are the criteria and methods of determining controllability?

LIEUTENANT-COMMANDER ROUNDS:—That is only a matter of opinion, unless we try to interpret records in the manner that the National Advisory Committee for Aeronautics tried to do. Arbitrary formulas intended to express a measure of maneuverability, which is certainly akin to controllability, have been attempted, but the pilot who has had the most experience in many varied types and with the greatest number of each type is the best bet on determining controllability in any particular airplane.

MR. GERHARDT:—No criteria for controllability have yet been established, but establishing a mathematical basis for this phase of performance is as important as for the maxima and minima of translational motion of the airplane, to which we now confine our tests.

Determining Landing Speeds Mechanically

A. C. HEWITT[7]:—Landing speed can be accurately determined mechanically. The determination could be made on a chassis dynamometer with a moving belt that was operated at variable speeds by electric motors and suitable tachometers. If the airplane were moving at the same speed as the belt, the wheels should not turn. If they did, that fact should be noted, and, by repeating the landings, the actual speed in feet per minute at the actual instant that the plane touched the ground could be determined. Whether the tail or the front wheel touched first would not matter.

What the public actually wants to know is how fast this plane is moving in relation to the ground at the actual instant that it touches the ground. This would seem to be a way of determining the thing mechanically and rather simply.

CHAIRMAN WRIGHT:—That method was tried out under Mr. Warner's supervision at the Massachusetts Institute of Technology several years ago.

MR. WARNER:—Yes, but not exactly as Mr. Hewitt proposed it. The landing was made on an ordinary runway and rate of spin of the wheel was recorded photographically. In a number of cases the same thing has been done with a speedometer on the wheel to record the rate of rotation directly, but that method is uncertain because of the time required for the wheels to become synchronized with the airplane and to catch up with the amount of skid of the wheel over the surface. So far as we can calculate it, that is probably small. The wheel is probably rolling truly with the airplane, if no bounce occurs before the machine has rolled 3 ft., and the skid is relatively small.

[6] Professor of aeronautics, College of the City of Detroit, Detroit.

[7] M.S.A.E.—President, Engineering Development Associates, Essex Fells, N. J.

Pioneer Work in Performance Testing

GEORGE B. PATTERSON[8]:—My experience with performance testing was more or less pioneering in nature. I was with the Army during the War and for a few years afterward when many of the methods discussed today were being developed.

The necessity for using recording instruments, particularly in small, single-seater pursuit airplanes, was appreciated early. Here the pilot has to do all the work himself, and every recording instrument that can replace an indicating instrument on the board is that much less labor for him in obtaining the needed data.

Obviously, accurate performance-results are very valuable for the airplane designer since they enable him to check his theoretical computations. They are most important in determining the relative military values of different airplanes and are extremely important nowadays in commercial work for determining the monetary value of any improvement or development that may be applied to an existing airplane or to a new airplane.

In 1919 we developed a trailing air-speed recorder that, when suspended below the airplane, gave the air-speed without the necessity for speed-course calibration. This recorder could be calibrated in a wind-tunnel. The entire mechanism was enclosed in a streamline shell with a pitot-venturi head mounted on its nose which reduced the time lag due to the air contained in the tubes from the head to the instrument itself. In a rapidly changing air-speed condition a considerable time lag occurs in the flow of air through very long tubes.

An interesting theory that Prof. Alexander McAdie of the Blue Hill Observatory deduced in 1920 by mathematical methods was that an airplane in the Northern Hemisphere should climb slightly faster in large, right-hand spirals than when flying straight ahead. He based that belief on the counter-clockwise cyclonic movement of the winds with increasing altitudes. We had determined that experimentally more than two years previously but had attributed it to other causes. An extremely slight increase in the performance in a right-hand spiral over that in a straight-ahead climb was noticed.

Commander Rounds spoke of the difficulty of correcting for variable and gusty-wind conditions in calibrating on a speed course. If a flight in one direction is made in a wind with a velocity of 2 m.p.h. greater than the wind velocity during the return flight, an error of 1 m.p.h. in the air speed is instantly introduced, assuming that the wind is parallel to the speed course. We found that much less error was introduced if a cross wind existed, because that wind gust then becomes a cosine error of the order of 0.1 m.p.h. instead of 1 m.p.h.

To relieve the personnel of certain work in speed-course measurements, we at first tried out electrical timing-methods requiring observation at either end of the speed course, and later with synchronously running stop-watches carried by ground observers. We then tested the method of having the pilot or the observer in the ship check the stop-watch time as the leading edge of his wing passed over the pylon. This last method proved satisfactory and was adopted. The accuracy obtained from the timing done in the ship was surprising and effected a considerable saving in personnel.

[8] Aviation division, Vacuum Oil Co., New York City.

Superchargers and Supercharging

(*Concluded from p. 78*)

chargers are used on aircraft engines not only to compensate for diminution of atmospheric pressure at altitude but also to boost the pressure *slightly* during take-off and during flight at low altitude. Mr. Moss, however, asserts that engines equipped with centrifugal superchargers are usually operated at positive intake-manifold pressures such that the net brake-horsepower is maintained constant at all altitudes up to the critical altitude and that at low altitudes a geared centrifugal supercharger still gives the engine a power reserve which may be used during take-off or emergencies. This means that such engines regularly develop gross power from 10 to 20 per cent in excess of their rated power, and that this overload may be at least doubled at low altitudes whenever the pilot elects to draw on his power reserve. Very few of the non-military aircraft-engine types are yet provided with superchargers, but it is evident that the Department of Commerce must ascertain the ability of such engines to withstand full-throttle operation at sea level and must seriously consider the efficacy of "throttle-stops" which the pilot can disregard at will.

The curves in the last section of the paper, comparing the effect of increasing compression-ratio and increasing compression-pressure on the performance of a single-cylinder engine, were obtained with benzol as a fuel to eliminate the effect of detonation. In recommending the approval of supercharged engines for use in air commerce, it is necessary not only to test their reliability on fuels of high knock-rating but also to determine the conditions under which they may safely be operated on fuels of lower octane number.

Electric-Furnace Cast-Iron

Milwaukee Section Paper

By H. E. Bromer[1]

MELTING in the electric furnace is the only means by which grey iron can be produced in quantities under absolute control, according to the author. Good iron can be produced from a cupola, but the cupola cannot be depended upon to produce uniformly good iron. Expensive alloys, which have been used to improve the quality of cupola iron for cylinder-blocks, can be eliminated by the electric-furnace method.

Results of tests of iron from regular electric-furnace production are charted and tabulated and comparisons are made with products of the cupola in the matter of Brinell hardness. Micrographs of electric-furnace and cupola iron are given for comparison, and the significance of the difference in their structures is explained.

Electric-furnace iron is said to be desirable for brake-drums, flywheels and piston-rings, as well as many other parts besides the cylinders and cylinder-heads which are considered more particularly in this paper. A great development in this method of melting during the next few years is predicted.

The discussion brings out the importance of Brinell readings or some other method of measuring hardness of cast iron. Hardness and wearing qualities are said to be much influenced by the handling which the casting receives in the mold. Superheating iron and pouring it at high temperature contribute to uniformity of structure and minimize internal strains.

Cost of iron melted first in the cupola and finished in an electric furnace is said to be approximately the same as that of cupola iron. Scrap iron can be used in the electric furnace, without the addition of pig, because the sulphur content is not increased in the process.

One discusser reports at length observations gathered during a tour in which many of the leading automotive foundries were visited.

IDEAL MELTING conditions would be obtained in a cupola if the charges of the various materials, including pig iron, steel scrap and cast scrap, were melted and mixed uniformly and absorbed exactly the right amount of carbon while melting and trickling down through the coke and if the air-blast and the amount of coke were proportioned correctly to prevent the passage of free oxygen to oxidize the iron. These conditions are so hard to obtain in actual practice that it is no wonder that cupola iron has earned an undesirable reputation for unreliability.

The chief metallurgist of a large producer of motor-cars showed great interest, when visiting our plant recently, in the quick test that can be made by the user of an electric furnace to determine the analysis and condition of the bath in the furnace. He wished that a similar test could be made on cupola iron, but he realized that it would be of no practical value because no change can be made in the iron after it is melted; the iron would be too cold for the addition of alloys by the time the test could be taken and read. The electric furnace offers the only means by which quantity production of grey iron can be had under accurate control.

The speaker does not wish to give the impression that good iron cannot be produced from a cupola; the difficulty is that the cupola cannot be depended upon to produce good iron regularly, because of the variations in silicon and carbon and in the melting conditions. This fact is recognized by all the leading metallurgists who have investigated the question or carefully checked the Brinell hardness of cylinder-blocks as received; it was the bane of my existence several years ago, in connection with the production of cylinder-blocks at the rate of more than 400 per day from cupola iron. Tests on every tenth block would show a variation of from 179 to 196 Brinell reading, 187 being desired, while occasionally a block of the same date in the production line would show a reading of 163 or even less than 156. The next block tested would be satisfactory, and invariably analysis of the soft block would show a carbon content much higher than the average.

TABLE 1 — REPRESENTATIVE SPECIFICATIONS FOR A CUPOLA-CAST CYLINDER-BLOCK

	Per Cent
Silicon	2.30-2.70
Manganese	0.50-0.70
Sulphur, maximum	0.10
Phosphorus, maximum	0.20
Total Carbon	3.00-3.50
Combined Carbon on Cylinder-Walls	0.40-0.60
Graphitic Carbon	2.55-2.90

Electric Furnace Yields Uniform Iron

Advantages of the electric furnace are many and varied. Chief among them is the uniformity of analysis and physical properties of the iron produced by this process. The importance of this feature to the automotive engineer cannot be overestimated, as it means that he is no longer obliged to depend upon the uncertain quality of cupola iron but can specify definite strength, Brinell hardness and analysis with the knowledge that every casting will measure up to his specifications.

A recent example of the type of specification which the automotive engineer must draw up, because of the unreliability of cupola iron, was shown on the blueprint of a current cylinder-block sent to us from one of the largest automotive manufacturers in the Country. This specification, which shows that the engineer who wrote it knew what he could expect to obtain from a cupola foundry, is given in Table 1.

Iron made within this specification might sustain transverse breaking loads ranging from 2500 to more than 5000 lb. per sq. in. and have Brinell hardness from 130 to more than 200. Such variations actually occur in cupola practice, so it is small wonder that one block is good and the next one bad.

The electric furnace has eliminated this difficulty, and

[1] Metallurgist, Standard Foundry Co., Racine, Wis.

TABLE 2—TEST RESULTS FROM 100 ELECTRIC-FURNACE IRON CYLINDER-CASTINGS

	High	Low	Average	Variation
High-Carbon Group, 20 Castings				
Brinell	207	196	198	11
Carbon, per cent	3.34	3.21	3.29	0.13
Silicon, per cent	3.25	2.08	2.15	0.17
Low-Carbon Group, 80 Castings				
Brinell	217	202	209.5	15
Carbon, per cent	3.20	3.00	3.08	0.20
Silicon, per cent	2.30	2.15	2.21	0.15

TABLE 3—TRANSVERSE BREAKING TESTS OF ELECTRIC-FURNACE IRON

	Number of Bars Tested	Average Strength, Lb.	Average Deflection, In.
Plain Iron	88	4,738	0.128
Low-Nickel-Chromium Iron	32	4,740	0.137
High-Nickel-Chromium Iron	42	4,738	0.130
Molybdenum Iron	41	5,400	0.157

TABLE 4—CUSTOMER'S REPORT ON ELECTRIC-FURNACE IRON

	Number of Bars Tested	Strength, Lb. High	Low	Average
Plain Iron	16	5,120	4,260[a]	4,747
Low-Nickel-Chromium Iron	7	4,860	4,540	4,690
Molybdenum Iron	10	5,520	5,100	5,253

[a] Only two bars were below 4,500 lb.

the engineer can now write a definite specification for both chemical and physical properties of cast iron similar to those he is accustomed to make for steel. Every other part of the engine has been held to definite specifications and within narrow limits for a long time; and now the cylinder and cylinder-head castings, the very foundation of the engine, can be controlled in a similar way.

Close Control Makes Alloy Unnecessary

The manufacturer who submitted the specification in Table 1 found it necessary with cupola iron to resort to a high alloy-content, costing more than $3 per cylinder-block, to maintain even an approximation of the desired uniformity in Brinell hardness. Since using electric-furnace iron, he has been able to greatly reduce the alloy content and discontinue the chemical specification. The manufacturer now specifies only that, if electric-furnace iron is used, each block must have a minimum Brinell hardness of 210.

Carbon is the most important element in cast iron, as its amount and distribution in combined and graphitic state control the mechanical and wearing properties of the iron. The amount of this element is controlled within very narrow limits in the electric furnace by the addition of steel for lowering the carbon content or by the use of petroleum coke for raising it.

Silicon also is an extremely important element, because of its influence on the carbon. It is well known that the relative amounts of graphitic and combined carbon are mainly controlled by varying the amount of silicon. This element also is controlled within narrow limits in the electric furnace.

An excellent example of what can be expected in actual electric-furnace practice in the control of silicon and carbon is afforded by the study of 100 cylinder-blocks that were made several months ago for the manufacturer of one of the highest-priced cars made in America. The production of the blocks extended over a period of eight days. As only 10 flasks were available, it was necessary during part of the time to make 10 castings each morning and afternoon, so the iron in these blocks represented various parts of the day's runs as well as the operation of the furnace during eight days. Determinations of Brinell hardness and carbon and silicon content were made on each of the 100 castings, and the castings were numbered so that they could be followed through the machine-shop and through their useful life.

Twenty of the 100 castings, made during two days, were given a slightly higher carbon range and a slightly lower silicon range to obtain lower average Brinell hardness in the bore than on the others, to determine if possible the effect of the higher carbon range on the machinability and wear resistance of the iron. The regular specification for these cylinders called for a Brinell hardness of 187 to 202 in the bore, and the group of 20 blocks was made to be comparable in this

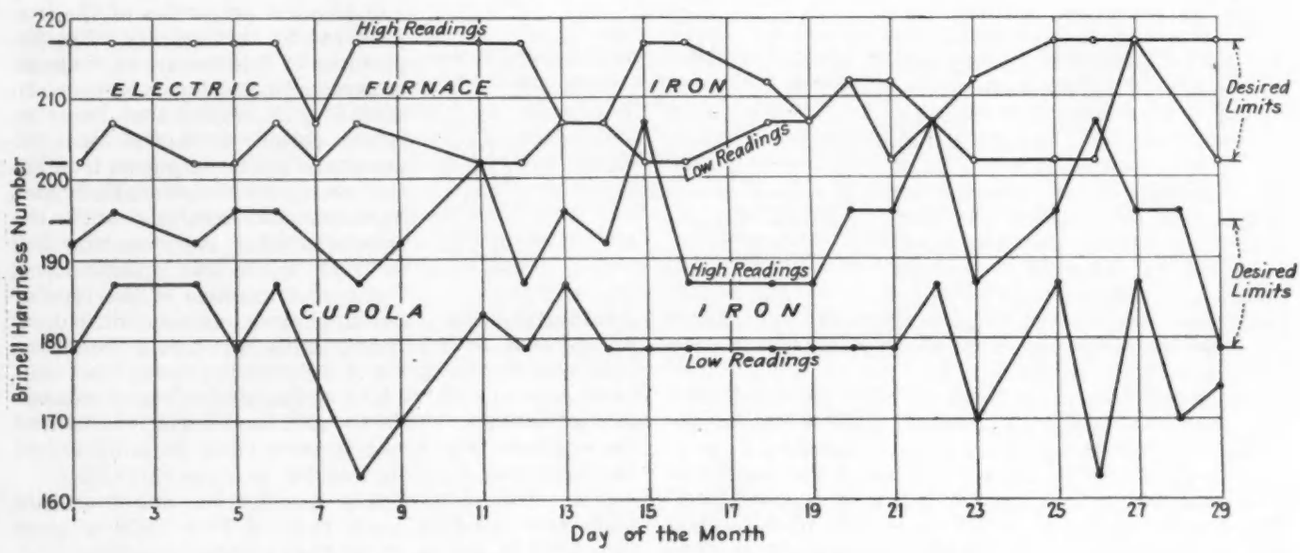


FIG. 1—BRINELL HARDNESS OF CYLINDER-BLOCK CASTINGS

High and Low Readings from Tests on Electric-Furnace and Cupola Iron during One Calendar Month, as Reported by the Customer. No Blocks Were Cast on the Days for Which no Dots or Circles Occur on the Curves. Different Brinell Limits Were Specified for the Two Kinds of Iron, as Indicated

respect with the cupola-cast cylinders. A summary of the results of tests of each of these groups is given in Table 2.

Melting Conditions Aid Uniformity

Uniformity of physical properties naturally follows from the uniform chemical analysis and the control of the melting and superheating conditions. Therefore it is not surprising to find the transverse strength, deflection, Brinell hardness and structure of electric-furnace iron uniform from day to day. Curves in Fig. 1, taken from actual reports of customers, show the high and low Brinell readings for the month's operation of the cupola and the electric furnace. Intersections of the upper curves indicate days when all the electric-furnace cylinder-blocks showed exactly the same Brinell hardness. The electric-furnace iron machined much more readily than the cupola iron, in spite of its higher Brinell readings.

The importance of Brinell readings or some other method of measuring the hardness of cylinder-blocks cannot be overestimated, and the uniformity of Brinell readings in various parts of the casting is significant. Superheating in the electric furnace contributes to this condition, as it produces a uniform structure throughout the casting, with even distribution of graphite flakes in both the thick and the thin sections. Microscopic examination proves this conclusively. Brinell tests on electric-furnace iron show an average variation of approximately 15 points between the cylinder-bore, the bearings and the cope flange, while Brinell tests of cupola iron at the same places show a variation of 40 to 60 points. This result is secured in the electric furnace without the use of expensive alloys, which do without doubt help to produce a more uniform structure in cupola iron. Alloys also have their proper place with electric-furnace iron, as the uniform base-mixture can be improved still further by this means when especially high strength is required.

Four grades of iron are in daily production in the electric furnace. A summary of tests made on these irons during December, 1930, and January, 1931, is given in Table 3, all the bars being the old standard American Foundry Association 1¼-in. round bars broken on 12-in. centers. These tests were made in the standard way in every respect except that the molds were made in green sand, which might give slightly lower results than the standard method of using dry-sand molds.

Of the 88 bars of plain iron tested, all but 17 were within the narrow limits of 4400 to 5000 lb. Seven were slightly below 4400 lb. and 10 were above the 5000-lb. mark. This record can hardly be equalled in daily production from a cupola, even though expensive alloys are used.

TABLE 5—PHYSICAL PROPERTIES OF IRON SHOWN IN FIG. 2

Transverse Strength, lb.	4,250
Deflection, in.	0.13
Rupture Stress, lb. per sq. in.	58,600
Tensile Strength, lb. per sq. in.	36,400
Repeated Impact, blows to fracture	2,368

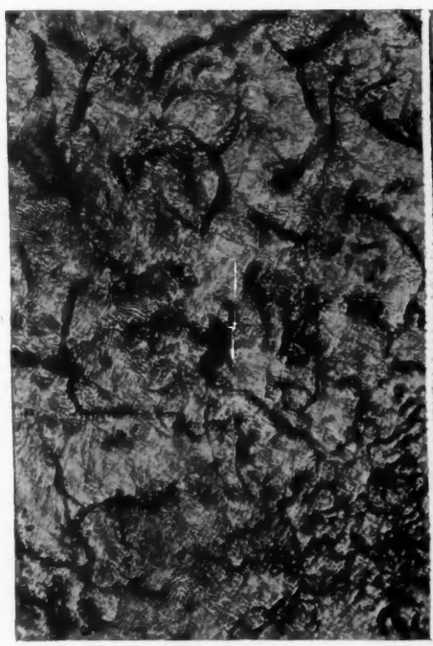


FIG. 2—TYPICAL MICROGRAPH OF ELECTRIC-FURNACE IRON

Etched and Magnified Approximately 400 Times as Reproduced; Brinell Reading 200 in the Bore; Analysis as Follows:

	Per Cent
Total Carbon	3.09
Combined Carbon	0.90
Silicon	2.34
Manganese	0.68
Sulphur	0.099
Phosphorus	0.159
Nickel	0.30
Chromium	0.11

FIG. 3—MICROGRAPH FROM A CYLINDER THAT WORE RAPIDLY

Etched and Magnified Approximately 200 Times as Reproduced; Brinell Reading 187 in the Bore; Analysis as Follows:

	Per Cent
Total Carbon	3.46
Combined Carbon	0.62
Silicon	1.88
Manganese	0.61
Phosphorus	0.218
Sulphur	0.092

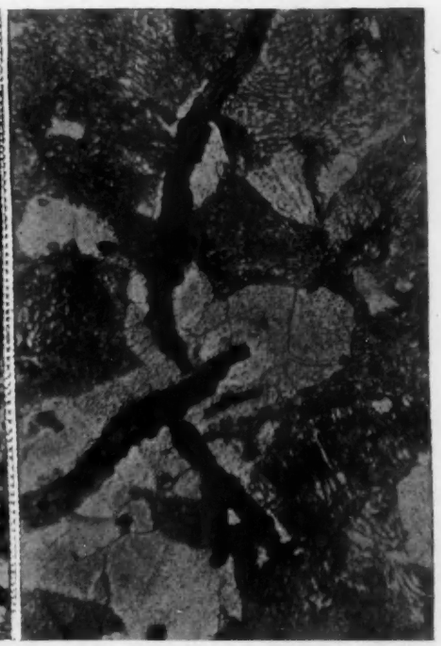


FIG. 4—MICROGRAPH FROM A CYLINDER THAT WORE WELL

Etched and Magnified Approximately 200 Times as Reproduced; Brinell Reading 163 in the Bore; Analysis as Follows:

	Per Cent
Total Carbon	3.46
Combined Carbon	0.36
Silicon	2.54
Manganese	0.63
Phosphorus	0.40
Sulphur	0.087

An interesting check on the results given in Table 3 is found in the report for the month of December, 1930, from one engine builder who tests standard 1¼-in. arbitration bars in his own laboratory. The results for the various types of iron made for him in our electric furnace are summarized in Table 4.

Tensile-strength tests have not been made regularly, but the average that has been found for plain iron is approximately 40,000 lb. per sq. in. on test specimens machined from 1¼-in. round bars. The average for low-nickel-chromium iron is about the same, while that for the high-nickel-chromium iron is about 45,000 and for the molybdenum iron about 50,000 lb. per sq. in. Special-alloy irons having a tensile strength higher than 60,000 lb. per sq. in., a transverse as high as 7000 lb. and a deflection of 0.18 in. have been made for certain jobs, but the cost for the alloys required is high enough to be prohibitive for ordinary work.

Three Cylinder-Irons Compared

All the electric-furnace irons listed in this paper are suitable for cylinder and cylinder-head castings in which the average section is from ¼ to ½ in. while many sections are only 3/16 in. and all the castings must be easily machinable. High strengths have also been obtained from the cupola by melting high-steel mixes containing special alloys, but such irons are suitable only for heavy castings and are entirely too hard for cylinder-heads or similar parts. A typical micrograph of electric-furnace iron is shown in Fig. 2, the analysis being given below it.

Micrographs in Figs. 3 and 4 are from cylinder-blocks of cupola iron of unknown origin. The cylinder-block represented in Fig. 3 was run only 500 hr. and showed a wear of 0.20 in. in the bore; while that shown in Fig. 4 was run 10,000 hr. with a wear of only 0.009 in. in the bore, but the valve seats cracked. A comparison of these two micrographs shows that the graphite flakes in Fig. 3 are smaller and less numerous than in Fig 4, the major portion of the structure consisting of pearlite interspersed with large particles of cementite or iron carbide with a small amount of ferrite. The pearlite is poorly developed in places, having considerable areas of iron carbide that has not been decomposed.

The three structural constituents shown in the micrographs are ferrite, pearlite and iron carbide, the Brinell hardness of which is 100, 200 and 800 respectively.

Tests on cylinder-blocks made from iron having a structure similar to that shown in Fig. 2 have shown excellent wearing qualities. The physical properties of the iron are listed in Table 5. This iron has fine, evenly distributed graphite flakes and the structure consists almost entirely of pearlite that is free alike from ferrite on the one hand and iron carbide on the other, which assures good wearing qualities and freedom from cracking and pounding in of the valve seats.

The large amount of iron carbide shown in Fig. 3 undoubtedly caused the rapid wear of this iron.

Fig. 4 shows virtually no iron carbide but considerable amounts of ferrite and pearlite, which fact accounts for the low Brinell hardness of the iron. The wearing qualities were good, because of the absence of iron carbide, which breaks out and acts as an abrasive on the cylinder-walls, but the iron is weak because of the large and numerous graphite flakes and the large amount of ferrite. This accounts for the cracking of the valve seats; failures of this type and the cases in which valve seats are worn by impact are invariably due to weak iron.

The usefulness of electric-furnace iron is by no means limited to cylinders and cylinder-heads; its high strength and other excellent qualities can be utilized to advantage for many other parts such as brake-drums, clutch plates, gear blanks, flywheels, die blocks, cable drums, piston-rings and in many other applications where high strength and uniform quality are essential. The application of electric-furnace melting to grey iron is still comparatively new; but many jobbing and automotive foundries are installing such furnaces, and the next few years will see a great development in this field.

THE DISCUSSION

WILLIAM F. KRENZKE[2]:—Is the Brinell hardness of cast iron proportional to its wearing quality or density?

H. E. BROMER:—It is a good indication of density and to some extent of wearing quality. High-Brinell iron in most cases will wear better than low-Brinell iron, but not always; the wear depends upon the structure.

C. E. FRUDDEN[3]:—How is uniformity of analysis obtained in the electric furnace?

MR. BROMER:—By taking tests of iron periodically, as often as is necessary, and having the man in control of the furnace make corrections before the iron is poured. From 7 to 9 tons of iron are carried in the bath; periodic taps of 1200 lb. each are taken out and the same amount is then added, thus maintaining this large bath throughout the day's run. This large quantity of iron helps to smooth out any variations. With the cupola, the iron must be taken as it comes from the spout.

JOSEPH B. ARMITAGE[4]:—Have engine manufacturers in general raised their specifications for Brinell hardness during the last year?

MR. BROMER:—There has been a definite tendency in that direction; for example, the builders of certain motorcoaches, who get their cylinder-blocks from us, are now asking for a minimum Brinell hardness of from 229 to 241 in the bore. The motorcoaches in question are used in New York City and travel about 12,000 miles per month, so they have experienced trouble with soft and weak iron. Another automobile manufacturer requires a minimum Brinell hardness of 210 on all cylinder blocks.

J. C. SLONNEGER[5]:—Experiencing difficulty not long ago from valve pounding, we found that the difficulty was due to the way we handled the castings after they were poured; they were not knocked out of the mold at the right time, and we found the valve seats to have a Brinell hardness of only about 140. We changed our methods and brought the hardness to between 196 and

[2] M.S.A.E.—Chief engineer, Jacobsen Mfg. Co., Racine, Wis.

[3] M.S.A.E.—Engineer, tractor division, Allis-Chalmers Mfg. Co., Milwaukee.

[4] M.S.A.E.—Chief mechanical engineer, Kearney & Trecker Corp., Milwaukee.

[5] M.S.A.E.—Consulting engineer, Milwaukee.

208, and then our difficulty with valve pounding disappeared at once. It is quite possible to have iron that is approximately right in the cupola and spoil it by improper pouring or handling in the mold. The electric furnace has the advantage of producing the kind of iron that is desired to pour into the mold, but it is still necessary to be just as careful with the pouring and handling.

My experiments with electric-furnace iron came to naught because the man who was conducting them insisted on pouring the iron at 2300 to 2400 deg. fahr., with very bad results. Much better results could have been secured with a temperature of 2700 to 2800 deg. I should like to know at what temperature Mr. Bromer is pouring iron.

I should like to know also how much more it costs to make electric-furnace iron because of the expense of both the cupola and the electric furnace. What is the kilowatt consumption per ton and the additional cost or selling price per pound?

Superheating Iron Helps Uniformity

MR. BROMER:—After checking the temperature at the spout for quite a long time, we have found that a temperature of about 2950 deg. fahr. gives the best results. Superheating the iron in the electric furnace aids in giving a very uniform structure throughout the casting, and this results in little internal strain. Normalizing or aging unquestionably relieves strains in the casting, but the internal strains in an iron of uniform structure such as is produced by the electric furnace are less than those in cupola-produced iron.

We produce electric-furnace iron at virtually the same cost as cupola iron and we sell it at the same price. The iron is melted first in a cupola and finished by the electric process, and the average electrical consumption, with tonnages of over 50 tons per day, is approximately 100 kw. per ton, representing a cost of a little more than $1.

CHAIRMAN J. R. FRANTZ[6]:—Are the addition of alloys and the type of pig iron used in electric-furnace iron of the same importance as with cupola melting?

MR. BROMER:—As the electric furnace gives a product approximately 30 to 40 per cent stronger than the cupola product for the same analysis, considerably more alloys are needed with the cupola. Large quantities of alloy are not needed with the electric furnace to smooth out variations, because uniformity is easy to obtain with the process.

Pig iron is used in the cupola to keep down the sulphur content; otherwise the sulphur will rise to what limits we know not. Three or four points of sulphur are added each time the iron is remelted. It is not necessary to use pig iron in an electric furnace. We have melted various heats in the electric furnace in which from 25 to 50 per cent of pig iron was used without securing any different physical characteristics than would be had from all scrap by the same process.

[6] M.S.A.E.—Vice-president, Le Roi Co., Milwaukee.

Observations from Foundry Visits

A VISITOR:—From the experiences that we have had in our foundry and my observation of what is being done by the Standard Foundry Co., I believe that all makers of automobile-engine cylinder-blocks will be obliged to adopt the electric furnace unless some other method is developed that will produce equal results. Recently I made a trip in which I visited some of the largest foundries in the Country in the automobile industry, together with the chief chemist and metallurgist of all three of our plants.

First we visited one of the largest Michigan foundries, which makes cylinder-blocks of many different types and so has to meet the same difficulty that we all have had first with L-head and then with I-head cylinders causing different structure in the metal. We told one of the men there some of our troubles, and he recommended that we call on the engineering departments of our customers for some help. We received the same advice from another source, and I believe that many foundrymen have been remiss in failing to secure cooperation from this source.

Then we went to one of the largest automobile plants, where 30 cupolas stand in a row and are now being replaced with 15-ton electric furnaces. A bath has just been completed in that plant which will hold 1200 tons of iron. The iron is delivered from a blast furnace directly into this bath. There are also two 220-in. cupolas. The mixture used consists of 60 per cent from the furnace and 40 per cent from the cupola, so the metal can be delivered to the electric furnace at a cost that is lower than ours, because of the saving in fuel secured from using the iron directly from the blast-furnace. The mixture can be controlled because the bath is so big.

We saw many wonderful things being done with the electric-furnace iron in that plant. Among the products are die-cast camshafts having a tensile strength of 50,000 lb. per sq. in. These look like drop-forgings as they come from the die. The castings go through a normalizing process before they are machined.

We discussed Brinell hardness in several plants and found that in some instances little attention is paid to it. It was reported at one plant that they try to get a Brinell reading of 170 and actually do get between 160 and 200. One plant we found to be experimenting with knocking out the barrel and valve-seat cores early in order to harden these surfaces. This procedure is still experimental, as there is some fear of cracks in the bores and valve seats.

A VISITOR:—I do not know that Brinell hardness is a measure of what is desired in a cylinder casting; in fact, I am not satisfied that we know just what we are looking for, as wear tests have not been extensive enough to determine that. Foundrymen undoubtedly have been somewhat careless with the cupola process in the past. No doubt there is room for a great deal of improvement in cupola iron and that much improvement will be made.

Rural Fire-Fighting Trucks

Southern California Section Paper

By J. P. Fairbank[1]

MANY variable factors must be considered when designing a suitable type of motor-vehicle for fighting fire in rural districts, according to the author. A rural fire-fighting truck may be called upon to attack forest, brush, grass and grain-field fires and fires involving structures on farms and in villages. The conditions to be met, as dealt with in this paper, are specifically in California.

Since a single rural fire-truck generally is the only piece of equipment in its district for fighting fire, it must be a general-purpose outfit. The roads that it must traverse may vary from pavement to mountain trails; from trunk highways to plowed fields. It may be required to climb 20-per cent grades and follow sharp curves with side clearances barely sufficient for automobiles. Sand and mud may be encountered on the same run; ditches and ridges must be crossed. It must carry its own water to fight grain and grass fires on the run. Its tank must be refilled from streams, irrigation ditches or wells, or it may stand and pump for long periods from such sources.

After describing the progress made in rural fire-truck development and analyzing the factors which govern the size and type of equipment, the author discusses the types of engine suitable for a rural fire-truck, desirable transmissions and rear axles, the design features of the fire-pump drive, body design, water tanks, wheel equipment, and accessories.

RURAL fire-fighting trucks are motor-trucks designed and equipped for fire suppression in non-urban territory. Popularly, such a truck is viewed as being an apparatus especially fitted for forest and brush-fire fighting; but, although this is an important field, its job does not end there. It must attack grass and grain-field fires, and fires involving structures on farms and in villages. That one truck may be called upon to attack fires of all these kinds makes the problem complicated, because many variables are involved.

The fire-fighting equipment of a large city is an outstanding example of the development of motor-vehicles to meet most exacting demands. A high quality of engineering and manufacturing skill backed by many years of experience enabled this development, but the problems have been relatively simple because the essential variables were few. The outstanding requirements have been dependability and capacity. No one city fire-truck is expected to meet all the exigencies of fire suppression; hence, the design can be made to fit a specific class of service. The road surface over which city fire-equipment operates is usually excellent, the grades are within reason, road clearance is not restricted and the speeds demanded are not excessive. The city fire-truck is not called upon to fight fire on the run; it can stand still to wage its battle, since its water supply is provided at convenient and uniform hydrants. It is operated and maintained by well-trained men under rigid supervision, and inspection is frequent and thorough.

The rural fire-truck has few of these advantages. A single truck is, in general, the only piece of equipment for the purpose in its district; hence, it must be a general-purpose outfit. The road surfaces it must traverse may vary from pavement to mountain trails; from trunk highways to plowed fields. It may be required to climb 20-per cent grades and follow sharp curves with side clearances barely sufficient for automobiles. Sand and mud may be encountered on the same run; ditches and ridges must be crossed. It must carry its own water to fight grain and grass fires on the run, and refill its tank from streams, irrigation ditches or wells, or stand and pump for long periods from such sources.

The operator of the rural fire-truck may be an excellent driver but, lacking the experience necessary to handle the apparatus calmly in the emergencies which always arise during a fire, he may subject the truck to severe abuse. The maintenance and inspection may be infrequent and superficial.

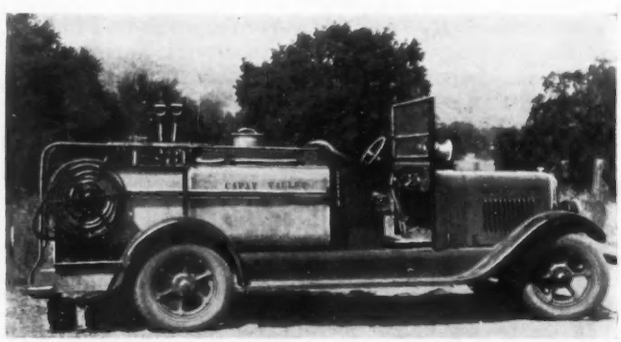


FIG. 1—A 1-TON RURAL FIRE-TRUCK USED IN A HILLY FARMING DISTRICT AND HAVING ITS FIRE PUMP DRIVEN FROM THE TRANSMISSION. THE REAR STEP IS TOO LOW

Limited finances may further complicate the problem. The general public is usually not enthusiastic about appropriating money for rural fire-fighting equipment. The purchase of a fire truck in a rural community is an important event, and proposals to that end are likely to meet opposition which may develop into bitter controversy. To avoid an impasse, therefore, the

[1] Extension specialist in agricultural engineering, University of California, Davis, Calif.

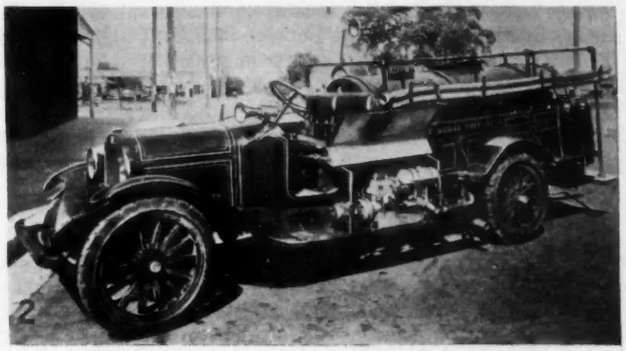
proponents may ask for an appropriation inadequate to purchase and operate suitable equipment. In the city, the purchase of a fire truck is submerged in the details of the municipal budget and does not afford the citizenry such a glowing opportunity for self-expression. A changing public opinion, improved organization, better roads and advanced mechanical design are all helping to remove the rural handicaps.

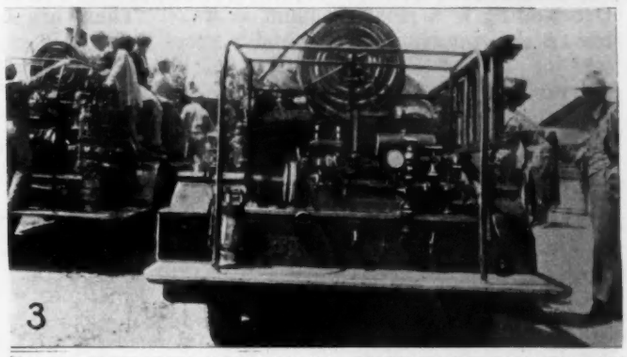
Progress in Rural Fire-Truck Development

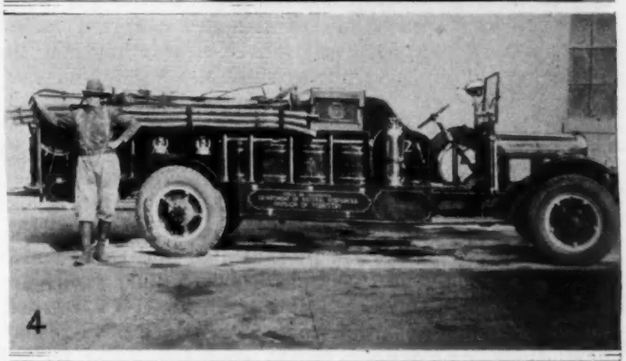
The use of motor-vehicles for grass and grain-fire suppression is not new. In 1917 and 1918 the Agricultural Extension Service promoted the formation in California of more than 200 rural fire-companies, primarily as a food-conservation measure. Many counties supplied their rural fire-companies with semi-trailers on which were loaded various hand tools, water cans, sacks and soda-acid fire-extinguishers. After a fire alarm, the first automobile to arrive at the fire station hitched to the trailer and towed it to the fire. These simple outfits did a great amount of good in that they provided a means of more effective fire-fighting and served as catalysts for community organizations. A few communities mounted the equipment on passenger-cars or light motor-truck chassis. Some equipped trailers and cars with chemical engines, an adaptation of light auxiliary equipment used in cities. Then farmers discovered that power sprayers were excellent for fighting grain and grass fires with water under high pressure, provided they could get the spray machines quickly to the fire. The next step was to mount the spray machines and water tanks on motor-trucks.

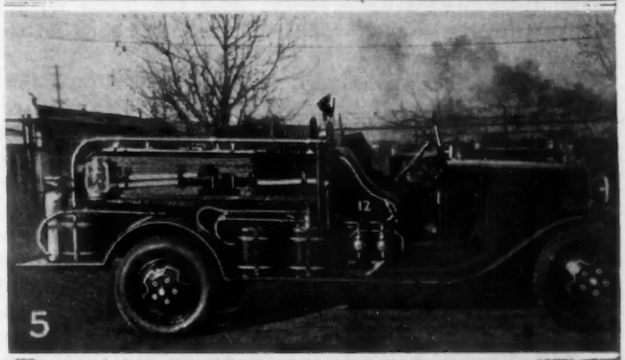
About 1920, tank trucks at Galt and at Oakdale, Calif., were equipped with light-weight forest-fire pumping-units. A number of recently built rural fire-trucks carry pumping units powered by small four-cylinder automobile or industrial engines; but the pumps on the majority of the new tank-trucks are driven by the truck engine. Although these various rural fire-trucks have not been entirely satisfactory, the experience of the last decade has shown them to be of great assistance in grain and in grass-fire suppression. This indicates that the idea should be developed further.

A tangible evidence of their value is the action of the Pacific Board of Fire Underwriters in making the organization and equipment of the fire district the basis for allowing credits on insurance on standing grain. Its experience has been satisfactory for two years, and the Board now proposes to extend similar concessions to insurance on structures where the fire-control organization and apparatus meet the requirements the Board has laid down. The tank pumper for grass and grain fires has proved its value. During the last two years









TYPES OF RURAL FIRE-FIGHTING EQUIPMENT

Fig. 2—An Early Type of Rural Fire-Truck Equipped with Two Forest-Fire Pumps, One Being Mounted on Each Running Board

Fig. 3—A Forest-Fire Pumping Unit Mounted on the Rear End of a Small Fire-Truck

Fig. 4—A 2-Ton Truck of the State Division of Forestry Which Has Good Road-Clearance and Low Over-All Height. The Fire-Pump Is Mounted on the Front End

Fig. 5—A 1½-Ton Truck of the State Division of Forestry. The Pump Is Driven from the Transmission

Fig. 6—A Six-Wheel Fire-Truck Weighting 14,850 Lb. and Having a Water-Tank Capacity of 425 Gal. It Has a Six-Cylinder 4¼ x 4½-In. Engine and the Centrifugal Fire-Pump Is Mounted on the Front End

its services have been extended to the forest and brush areas by the U. S. Forest Service, the State Division of Forestry and by some county organizations of which the Los Angeles County Forestry Department is an outstanding example. Rural fire-trucks are being welcomed into city fire-departments for use in fighting grass fires and for safeguarding the burning off of vacant lots and border areas remote from hydrants.

Size of Rural Fire-Truck Chassis

The size of rural fire-trucks now in use ranges from ¾ to 5-ton rated-capacity. Of the modern trucks, the common size is 2 to 3 tons. The State Division of Forestry now has six 2-ton and six 1½-ton outfits. Overloading is a most frequent mistake. There are 1-ton trucks staggering along under gross weights in excess of 7000 lb., and 2-ton trucks have been found carrying 10,000 to 12,500 lb. gross weight. The remarkable thing observed is the absence of breakage. As a rule the overloaded trucks are sluggish; but, in general, they stand up. Some of them have been equipped with overload springs, and occasionally 2-ton trucks have been purchased with 3-ton rear-axles.

It seems that, no matter what size of chassis is used, it is likely to be overloaded. Naturally, the firemen want to carry a large quanity of water. Sometimes we find 500-gal. tanks on 2-ton trucks, and 300-gal. tanks on 1½-ton trucks. It is realized that the tonnage rating is an unsatisfactory way to compare different makes and sizes of chassis, but it is the only method the automotive engineers have given us. A 500-gal. tank of water does not seem to be an overload for a 2-ton truck; but, including the weight of the body, hose, equipment and men, it is evident that the truck is likely to have difficulty on hills and in fields. In grain areas, 300 gal. is enough for a 2-ton truck. The 2-ton trucks of the State Division of Forestry have 200-gal. tanks, but they are used mostly in the hills, and carry much extra equipment; for example, 1000 to 2000 ft. of fire hose. Since mobility is a prime essential in a fire truck, those who have anything to do with design or recommendations should endeavor to keep the gross weight well within the capacity of the chassis. If they do not do so, no one else will.

The Pacific Board of Fire Underwriters published Suggested Specifications for Grass and Grain Fire-Trucks in 1929. The preparation of these specifications was a most constructive step in outlining the minimum requirements for this class of apparatus. The Agricultural Extension Service had made a survey of existing rural fire-trucks, observed their performance as to satisfactory and unsatisfactory features, and compiled data on their design. On the basis of this survey and the experience of automotive engineers, fire wardens, forest-service officials and underwriters' engineers, the suggested specifications were drawn up for rural fire-trucks of the tank-pumper type. Some of the items in these specifications were necessarily somewhat indefinite and empirical, but the object was to avoid some of the flagrant mistakes which had been made by the earlier builders of rural fire-trucks and yet not to suppress progress by too rigid standardization.

The committee specified a chassis of not less than 2 tons nominal rating, with the restriction that the total weight of body and load shall not exceed by more than 25 per cent the truck manufacturer's body-and-load allowance. This overload allowance is generous, considering the class of service, especially for those manufacturers who are inclined to be optimistic on the tonnage ratings of their chassis. On the other hand, extreme conservatism might defeat our goal of mobility because of an unduly heavy and unwieldy machine. Further, the factor of cost cannot be disregarded.

The recent improvements in municipal fire-trucks which exemplify the advances in automotive engineering, such as new alloys, new shapes of members, and four-wheel brakers, are very encouraging. The rural fire-truck of the future may show the influence of the airplane, particularly as regards the use of non-ferrous alloys to reduce weight. The light alloys may be used for water tanks, bolsters, bodies, piping and pumps. Automotive engineers are building aluminum bodies for commercial trucks and buses; therefore, why not use aluminum-alloy water-tanks on fire trucks? The State Division of Forestry is building a truck with a duralumin tank, thus increasing the water capacity with no additional gross weight.

Engine Suitable for Rural Fire-Trucks

Experience has shown that adequate engine-power for rural fire-trucks is an item of major importance. These trucks must make long runs at 40 m.p.h. or faster and be able to travel up long hills and over soft ground. Auxiliary or compound transmissions have given these trucks a performance which otherwise would have been impossible with the average commercial-truck chassis equipped with an engine of normal size. Low gear-ratios are an aid to, but not a substitute for, power. As would be expected, it is found that trucks with gross weights in excess of 10,000 lb. that have engines which peak at 60 to 70 b.hp. are logy. With the compound transmission, the engine can turn the truck wheels under practically all conditions, but the time lost on a long mountain climb may prove serious or even disastrous. The fire will not wait for the apparatus.

During the last year we have noted the improved performance of trucks powered with 85 and 90-hp. engines, even though the weights of the chassis were somewhat greater. The most remarkable hill performance we have witnessed was that of a fire truck of 8500-lb. gross-weight having a 120-hp. engine. This power-weight ratio probably is beyond practical limits for the immediate future, but the trend should be in that direction. As in trucks used for other industrial work, high torque at relatively low engine-speeds is desirable for rural fire-trucks. In the designs in which the truck engine also drives the fire pump, the pump load on the engine must be added to its load due to moving the truck, at slow speeds to be sure, but often on a hard pull. Assuming a pump and transmission efficiency of 50 per cent, about 12 hp. is required for 100 gal. per min. at a water pressure of 100 lb. per sq. in.

That fire-truck engines have had their cooling troubles is not surprising when we consider that they may make long runs in hot weather at slow speed with nearly full throttle. Some have heated seriously even under more favorable conditions. The necessity for bypassing water from the fire pump through the cooling jackets or radiator should be avoided. The cooling capacity should be large, even at the disadvantage of a lower thermal efficiency for the engine.

Desirable Transmissions and Rear Axles

At the time the suggested specifications were drawn up, the 2-ton trucks were commonly equipped with three-speed transmission, 6 1/3 or 7½ rear-axle ratios

and engines that peaked at about 50 b.hp. and developed maximum torque at about 1000 r.p.m. Consequently, the trucks could not run slowly along a fire line, but had to move and stop at frequent intervals. Practical fire fighters said that, for grass and grain fires, they wanted the trucks to move along the fire line at a constant rate and maintain steady water-pressure on the hose lines; further, that in some cases the truck speed should be about 1 m.p.h. To accomplish this would have required using a 36-in. tire that would turn at about 9 r.p.m., and, with an engine speed of 1000 r.p.m., would need a first gear-ratio of 111:1. Even with engine speeds of 600 r.p.m., the ratio would need to be close to 70:1. Hence, with three and four-speed gearsets, the practical solution was to use auxiliary transmissions, even with the liability of over-stressing rear-axle members. Thanks to the S.A.E. steel specifications, over-stressing has seldom materialized.

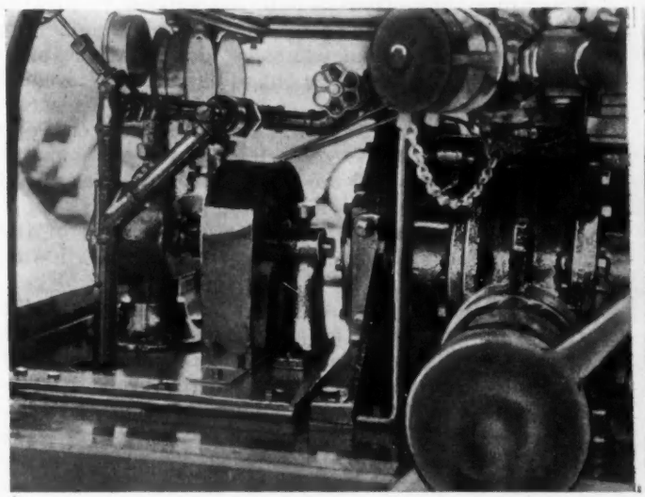


FIG. 7—FIRE-TRUCK EQUIPPED WITH TWO TYPES OF PUMP

The Small Rotary Pump at the Left Has a Capacity of 30 Gal. Per Min., and Is Driven from a Power Take-Off. It Is Used for Fighting Grass Fires While the Truck Is Moving. The Pump at the Right, of 500-Gal. Per Min. Capacity, Is Used When Pumping from Hydrants and Other Plentiful Sources of Water Supply

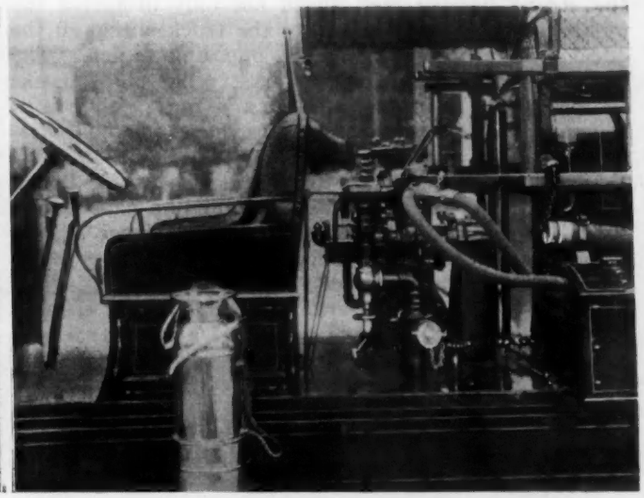


FIG. 8—AN EXAMPLE OF A FIRE-PUMP MOUNTED AMIDSHIPS AND DRIVEN BY SILENT CHAIN FROM A POWER TAKE-OFF

Design Features of the Fire-Pump Drive

Aside from the requirements for moving the fire trucks at slow speeds, many of the fire pumps, as driven, require an engine speed of at least 1000 r.p.m. to assure sufficient water pressure. This factor can of course be ignored where the pump is driven by an independent engine. The design problem also is simplified when the fire pump is independently driven, but the selection of the engine for that purpose is of concern to automotive engineers. Because of some unfortunate experiences, the Pacific Board of Fire Underwriters has stressed dependability, adequate power and quick starting.

The recent developments of small industrial engines by manufacturers of long standing provide a number of types from which to choose. In brief, the features suggested as desirable are a four-cycle engine having not less than two cylinders; a high-tension waterproof magneto equipped with an impulse starter; a gravity fuel-feed equipped with sediment trap and screen; and an engine governor. Although it is not so stated in the specifications, it now seems desirable that the pump powerplant should be completely equipped with a radiator and a fan and should not be dependent upon cooling-water bypassed from the fire pump. Air-cooled engines may find a place in this service.

The chief objections to driving the pump by an independent engine are the weight and the space required by the engine. In by far the greater number of rural fire-trucks now in use in California, the fire pumps are driven by the truck engine through a power take-off either on the transmission or on the front end of the crankshaft. Opinion is divided as to which is the better practice. Driving the pump from the transmission permits greater latitude in the size of the pump, in mounting location and in piping arrangements. Since the drive is back of the engine clutch, the pump slows down when the gears are shifted and, with standard power take-offs, it is difficult to shift gears while the pump is engaged. Some firemen have suggested that the pump drive be mounted ahead of the clutch, but this would present a difficult problem for the designer.

The status of the power take-off drive was unsatisfactory three years ago. Some of the transmissions had no provision for power-take-off attachment, or, if one was provided, it was only the small type suitable for tire pumps and hoists. Transmissions generally have large power-take-off openings now, and many power take-offs are designed for constant duty. Because their designers lacked experience and design data, some of the early pump drives have been somewhat unsatisfactory. The causes of trouble have included countershafts from the power take-off mounted in cast-iron pillow-blocks, long chain-drives which would whip, and shafts so inadequately supported that the chains would climb the sprockets when a full load was put on the pump. Those who are experienced in machine design and have factory facilities at their disposal are in a position to give us pump drives which are adequate and dependable.

Pumps mounted on the front of the truck and driven directly from the crankshaft permit a very simple power take-off, but one which must be modified for each model of truck. Shifting gears does not stop the pump nor does the pump interfere with shifting

gears. The installation can be made quickly when the necessary parts are furnished by the pump manufacturer, but long pipe-lines are required between the tank and the pump. The original designs of jaw clutches were inconvenient in that the pump could not be engaged from the driver's seat. In some cases when the truck frame was in a twist, the pump could not be engaged. These difficulties have been overcome in some recent designs which incorporate combination friction and jaw clutches operable by the driver.

Some persons object to front-end mounting because of possible damage to the pump in case of collision. That objection is not serious where the pump is protected by a substantial bumper placed well ahead. Pumps have been damaged by collision but, in one case, the strong bumper well ahead not only protected the pump but prevented damage to the truck, although the effect was rather severe on the opposing vehicle. The California State Division of Forestry has eight trucks equipped with front-end pumps, and four with pumps mounted amidships. Both types have proved satisfactory.

For the grain and grass-fire trucks, the Pacific Board of Fire Underwriters specifies a minimum capacity of 30 gal. per min. at a pressure of 120 lb. per sq. in. However, where the insurance rate on structures is involved, the minimum capacity is 100 gal. per min. The rural fire-trucks now in service, aside from the regular pumpers of city type, have pumps of a capacity ranging from 30 to 400 gal. per min., the majority having a capacity of 50 to 100 gal. per min.

Body Design, Water Tanks and Wheel Equipment

So great a variety of small equipment must be conveniently located and safely carried on rural fire-trucks that the ingenuity of the designer is severely tested. Wide and low running-boards, so popular for metropolitan fire-trucks, have no place on rural fire-trucks. The specifications state that rear steps or platforms must be at least 24 in. above the ground. Spare tires should not be carried under the frame, because of impaired clearance when crossing ditches or embankments. Placing objects below the frame amidships should be avoided, because full clearance is needed when crossing ridges. On some designs, auxiliary transmissions and piping are offenders in this regard.

The majority of the water tanks have been constructed of No. 12 or No. 14-gage steel with welded joints. Baffle plates reduce surge. It is important that the center of gravity of the tank of water be low, as the surge of water has a marked effect on steering. Trucks loaded with water have been upset on turns at speeds which would have been safe with an unshifting load. Tanks of elliptical cross-section have advantages in structural strength and reasonably low center of gravity, but it is less difficult to incorporate rectangular tanks into a neat and convenient design.

Rigid pipe-connections should be avoided to prevent rupture at the tank. The top of the tank should have ample openings to avoid excessive plus or minus pressures when pumping into or out of the tank. Manholes or large coverplates make for convenience in construction and repair. With but one suction-outlet, long water-tanks cannot be completely emptied when the truck is on a hill. The trucks built for the California Division of Forestry by the Division of Highways shops are provided with a suction outlet at each end of the tank, controlled by a three-way valve in the main suction line to the pump.

Dual rear-wheels are widely accepted for fire trucks in the grain and grass areas; but, in districts where rocks, ruts and narrow roadways are encountered, single rear-wheels seem preferable. There the problem is to choose one size of tire large enough so that the rear tires can carry the load and that the front tires have sufficient clearance to allow the truck to make the necessary short turns. Smaller tires in front make two spare tires necessary, and it is hard enough to find a place to carry one spare tire.

One way to avoid this difficulty is to use the six-wheel truck with tandem rear-axles. Such a truck was put into service last year in Riverside County, Calif., and gave excellent results. A few bad grain fires got out of control last year because fire trucks with single rear-axles stalled

FIG. 10—A HEAVY PASSENGER-CAR CHASSIS CONVERTED INTO A RURAL FIRE-TRUCK WEIGHING 8500 LB. AND HAVING A 120-HP. ENGINE

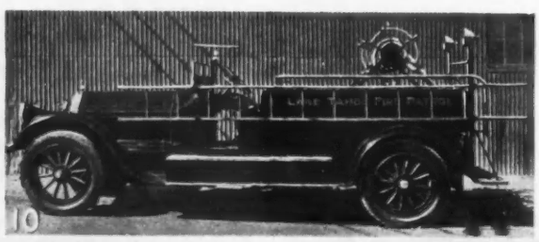


FIG. 9—A TYPE WHICH HAS A HIGH REAR-PLATFORM AND ILLUSTRATES ONE METHOD OF MOUNTING THE SPARE TIRE TO AVOID REDUCING THE GROUND CLEARANCE

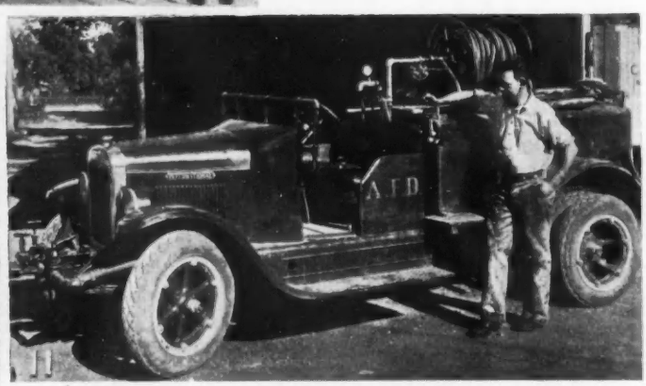


FIG. 11—HOME-MADE RURAL FIRE-TRUCK EQUIPPED WITH A FIRE-PUMP MOUNTED ON THE FRONT END OF A SMALL SIX-SPEED CHASSIS

in sandy soil. A six-wheel truck was tried later under the same conditions and operated satisfactorily. A fire truck's ability to keep going is a prime essential. The indications are that more six-wheel trucks with tandem live-axles, and other four-wheel drives, will come into use when the public is convinced that the additional cost is justified. There will be an increasing demand for such trucks in sizes smaller than 2 tons.

We have had cases of rural fire-trucks that started fires from their exhausts. Therefore, a problem for the automotive engineer is to design an exhaust system which cannot start a fire in tall grass or grain from sparks, flame or hot surfaces. It may also be well to consider using certain types of air-cleaner to prevent backfiring from the carbureter.

Summary

(1) Rural fire-trucks as used in California are equipped with water tanks, small fire-pumps, hose, fire extinguishers and hand tools useful in fighting fires in grass, grain, brush, forest and structures.
(2) They must meet a far greater range of conditions than do urban fire-trucks.
(3) Their development originated with crude adaptations of available equipment for fighting grain and grass fires.
(4) Their acceptance has been promoted by reductions in insurance rates.
(5) Mobility and dependability are prime requisites.
(6) Overloading has been a common fault.
(7) The power-weight ratio should be increased.
(8) Multi-speed transmissions are desirable.
(9) Fire-pump drives require careful design.
(10) The center of gravity should be low, yet ample road-clearance must be provided.
(11) Provision must be made for carrying a large variety of small equipment that is easily accessible.
(12) Dual tires should be avoided for trucks intended for use in mountainous areas.
(13) Driving with four wheels is desirable, especially on loose surfaces.
(14) The exhaust system must be safeguarded against starting fires in dry grass and grain.
(15) Automotive engineers can help greatly in further development of rural fire-trucks.

Reducing the Height of a Car

Floor and Seat of 1931 Auburn Lowered to Reduce Car Height Without Sacrificing Headroom[1]

OBTAINING headroom over the rear axle is the greatest problem in reducing the over-all height of a rear-drive car. Approximately 5 in. must be allowed between the axle and the frame for sufficient spring motion to secure good riding, and 3 to 4 in. more is required for frame depth. This determines the height of the top of the frame. Placing the cushion on top of the frame brings it altogether too high, so it became necessary for us to spread the side rails so that the cushion could go between them. To do this, we increased the tread of the rear wheels to 61 in., moved the springs and side rails outward as far as possible and dropped the seat-pan below the top of the side rails.

When the frame comes down to the axle, the center of the axle housing extends higher than the bottom of the seat-pan. In many cases a metal cover is put over this opening and short coils are used in the cushion spring at the center, which affects the seating comfort. To overcome this objection, we finally decided to cut a hole in the seat-pan to clear the axle housing and cover it with a rubber disk, making the cushion straight with full-length coils. A test was made by setting up a car as proposed and bouncing it with a passenger sitting in the middle of the back seat. It was found that, when the housing bumped through, none of the shock was conveyed to the passenger, as the compression of the cushion springs absorbed it.

Reducing the height of the floor was the next problem. The center line of the engine at the front of the propeller-shaft is determined by the ground clearance needed under the flywheel housing. A common method of bracing the frame is to place a cross member over the propeller-shaft. Allowing the conventional section of 2 to 3 in. for this cross member over the propeller-shaft at the bumping position of the frame and axle made the floor altogether too high for the height of body which we desired.

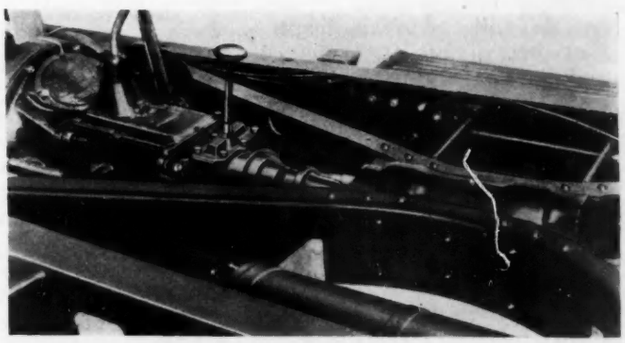


FIG. 1—CROSS MEMBER OF X FORM ON AUBURN CAR

We therefore designed a cross member of X form, made from two channels having their open sides toward the center of the car. The rear end of each of these channels is fastened to the side rail just back of the front end of the rear spring, and the front end is attached just in front of the engine support. These channels come near to each other at the center of the car, and metal plates are riveted to the top and bottom to form a box section at the center of the car through which the propeller-shaft extends, as shown in Fig. 1. The floor is in the form of a pan dropped below the sills, so that the bottom of the floor is in line with the top of the frame.

This arrangement brings the top of the frame 2 to 3 in. lower than with the old design.

[1] From a Chicago Section paper by Herbert C. Snow, M.S.A.E., chief engineer, Auburn Automobile Co., Auburn, Ind.

Urban Motorbus Maintenance

Chicago Section Paper

By George Hind [1]

A MAINTENANCE system which is adequate, efficient and economical, based on records and supplemented by eternal vigilance, controls the fleet of 393 motorbuses operated by the Detroit Motorbus Co. from five garages in Detroit, of the type shown in Fig. 1. The vehicles cover approximately 13,000,000 miles per year, and each is scheduled for inspection over a well-lighted pit after each 2500 miles of operation.

Inspection data obtained at this time, together with the data recorded on the inspection sheets from the driver's written defect-reports and confirmed by the night inspector, enable the foreman to determine the amount of work needed to put a vehicle in first-class condition. This history may warrant repairs to the original units or the changing of any chassis unit. At this inspection, every unit is examined and needed adjustments are made. The engine oil is changed and the old oil is stored in barrels to be reclaimed. About 10,000 gal. of oil is reclaimed per year as an average. All chassis units are thoroughly lubricated. The generators are removed at every second inspection and sent to the main repair-shop to be cleaned, examined and repaired if necessary. As their bearings are packed with grease, oil is not necessary between inspection periods and the generator records show this procedure to be the most efficient. Similiarly, air compressors are also sent to the main repair-shop and spare units are substituted. The motorbus body and all electrical equiment are examined closely and, during this procedure, the body is washed inside and out with soap and water. This is the only time when soap is used on the body, and great care is taken not to injure the panel work.

Five garages in Detroit are used as headquarters for housing and servicing the 393 motorbuses operated in city service by the Detroit Motorbus Co. Each vehicle is inspected thoroughly after each 2500 miles of operation. The author gives details of this inspection and says that the condition of the motorbus body governs the decision as to when a complete overhaul of the vehicle should be made. The overhaul period may range from two to five years, according to the locality in which the vehicle has been operating and the conditions under which it has been operated.

Complete overhauls are made in the main repair-shop, which is divided into separate departments each equipped with tools and machinery for handling all classes of work. During the last two years the company has built 288 motorbus bodies, the majority being of 29-passenger capacity. The company focuses more than ordinary attention on storage-battery maintenance. All of its vehicles are equipped with voltage regulators which, it has been found, are advantageous in that they reduce storage-battery costs. The author concludes that cleanness is essential to good maintenance.

If good maintenance practices are followed at the general inspection, it is natural to assume that the chassis remains in first-class condition and there should be no reason for an annual overhaul. This being true, the condition of the body governs the complete overhaul which may take place after periods ranging from two to five years, according to the locality in which the bus has been operating and the conditions under which it has been operated. Each bus is completely painted each year, and partial painting jobs are done if needed after accidents. A spray booth capable of turning out two complete single-deck buses in the 8-hr. day is always occupied. A photograph is taken after accidents which cause damage to the bus of more than $50, and a special card is issued to facilitate the segregation of costs. This procedure has proved invaluable in settling disputes.

Buses subject to complete overhauls are sent to the main repair-shop, a building occupying an area of 38,000 sq. ft. and equipped with tools and machinery to handle all classes of work. Its departments include electrical, tinsmith, blacksmith, welding, engine, transmission, pipe-fitting, upholstery, sign-making and painting, and storerooms. The body and the chassis dissolve partnership in this shop and each proceeds down its own respective line while undergoing repairs of a major character. Either a new or a repaired body is mounted before the overhauled vehicle enters the spray booth for painting.

During the last two years we have built 288 bus bodies, the majority of which were of 29-passenger capacity, as shown in Fig. 2. Another type is shown in Fig. 3. The age of the bodies scrapped ranged from three and one-half to eight years, but partial overhauls had been made during these periods. The bodies that were scrapped after three and one-half years had unseasoned maple posts

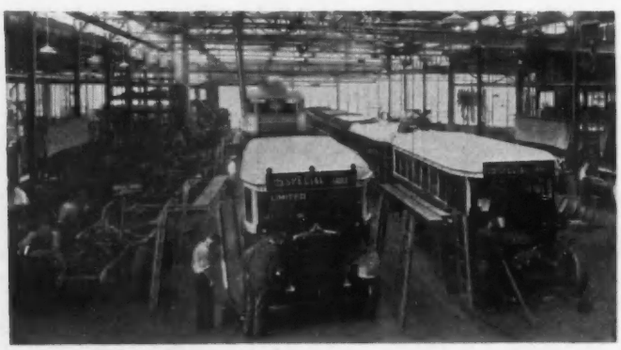


FIG. 1—A PORTION OF ONE OF THE FIVE GARAGES USED

[1] Superintendent of Maintenance, Detroit Motorbus Co., Detroit.

and sills, to which their short life can be attributed; but the life of a wooden body equipped with ash posts and sills varies between six and eight years. In the building of these new bodies production methods were introduced as well as new ideas. The sides and ends were made on jigs and bolted together. Each post was subjected to a bath of creosote at a temperature of 160 deg. fahr. for 4 hr. and was allowed to dry before being given two coats of asphalt paint. This applied only to the portion of the posts that were to be covered later by sheet metal. Wooden posts destined to be painted are treated with Lionoil. Our new bodies were made from the finest seasoned white ash. An examination of the first body built showed the wood to be well preserved after two years of operation.

Adequate Battery Maintenance Essential

Battery maintenance is very important. In 1925, with about one-half the fleet protected by voltage regulation, the average life of storage batteries on our buses was 16.3 months. Since then the fleet has been completely equipped with voltage regulators and, due to improvements in their construction, better maintenance methods and the use of an improved type of battery more ruggedly built and designed especially for motorbuses, the battery life has been increased so that, in 1930, the average life of batteries before being scrapped was 27.3 months.

The most vital points of good and economical storage-battery maintenance on motorbuses in our experience are strict attention to the operating voltage of the voltage regulator, weekly inspection and watering of every battery, with care used not to over-fill the cells so that, when the battery temperature rises during charge, the electrolyte will not expand, be forced from the jars and cause a gradual falling off of the specific gravity of the electrolyte with consequent damage to the battery case or compartment. A card having a space for each day of the month is used to assure that no battery is missed at inspection periods. The buses are listed on this card and must be checked off as having had batteries watered within the one-week period in every case. These cards are sent to the electrical foreman at the end of each month. Electricians will not make false entries, because they know that the battery may require attention at some point where it would be impossible for them to conceal their own neglect.

Absolute cleanness of battery terminals is essential. The terminals are removed and cleaned, and vaseline is then applied to reduce corrosion. The battery is removed and thoroughly washed with warm water from a hose. This is done at the general inspection after 2500 miles of operation. All batteries in our fleet are placed in compartments within the bus, as they are more easily kept dry and clean. On double-deck buses, batteries are in compartments in the driver's cab; on single-deck buses they are placed under the driver's seat or in a compartment at the left of the driver's seat.

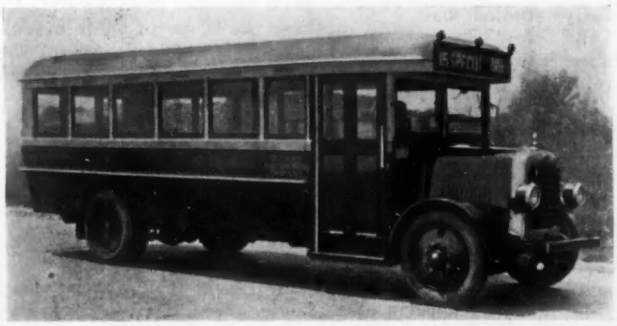


FIG. 2—TYPE OF 29-PASSENGER BUS USED BY THE DETROIT MOTORBUS CO.

FIG. 3—LARGE TYPE OF MOTORBUS USED BY THE DETROIT MOTORBUS CO.

Voltage Regulators Aid Maintenance

If the voltage regulator is properly set and the battery is in good mechanical condition, there is no possibility that any acid fumes will enter the bus. If the regulator should be out of adjustment or the batteries in bad condition, the driver's report of an acid odor is a sure indication that some trouble exists. Our batteries have a deep sediment-space beneath the plates to receive active material shed through wear. We find that the battery elements are worn out so nearly together that it does not pay to make renewals of any part unless the battery has had some unusual experience to cause a repair to be made before it is worn out. This is illustrated by the fact that, during 1930, our repair bill on a fleet of 393 buses was only $135.64; and this was largely for the replacement of wooden cases.

All of our buses are equipped with voltage regulators, and we find them a great advantage in reducing battery costs. During 1930, the cost of regulator maintenance was $2.814 per bus, including labor and material to recondition 580 batteries in our electrical repair-shop. Each garage has a voltmeter, and the electricians are constantly checking the regulators to discover those in which the voltage setting has risen above the danger point or fallen below the point of efficiency. The constant-potential voltage on regulators with one carbon and one metal contact operated in conjunction with third-brush generators carrying a charging rate of 3 amp. greater than the lamp load are adjusted to 40 amp. and 14.5 volts for summer operation, and to 40 amp. and 15 volts for winter operation. The voltage settings are in all cases established with the regulator warmed up to duplicate an operating condition in service.

Current and voltage-control boxes are in every case used in conjunction with straight shunt generators. In experimenting with platinum-alloy magneto-contacts for the stationary contact in voltage regulators having metal contacts, we have had very gratifying results.

Cleanness is essential to good bus maintenance. Well-lighted and well-ventilated garages, clean pits and a good spray system of washing buses are the factors of greatest importance in keeping the mechanical department's morale at a high standard and maintaining the vehicles in perfect condition.

Transportation Engineering

Coordination of Transport

Elisha Lee Outlines Policy That Will Mutually Benefit Railroads and Motor Transport

ADDRESSING members of the National Petroleum Association recently, Elisha Lee, vice-president of the Pennsylvania Railroad, summarized this railroad's reactions to the new conditions in transportation, its attitude toward the other means of service, and the course it expects to pursue in the future. He said in part that certain controlling fundamentals appeal to his company. Perhaps the first is that neither individuals nor institutions can stand in the way of progress. The public is entitled to the full benefit of every real advance in the art of transportation, no matter by what agency it may be rendered. Mr. Lee continued as follows:

The day has long passed when railroads should be looked upon as limited to the rails alone. The physical plants of the railroads are still our most important and valuable means of transportation, and seem likely to remain so indefinitely. On the other hand, the railroad companies, as business organizations, should henceforth be regarded as corporate enterprises existing for the purpose of providing any form of transportation service for which there is a real need or demand. They should stand upon an equal footing with all other companies or individual citizens in this respect, and laws which restrain them from rendering useful service or which discriminate against them should be changed in the public interest.

Railway, highway, airway and waterway transportation should be intelligently coordinated to the end that the public may enjoy the maximum utility of each in its most efficient field. Wasteful and uneconomic competition between the different agencies, and overlapping of their operations, serve no good purpose and merely make service more costly. By proper coordination this can be largely, if not entirely, avoided.

We believe that the railroad companies, from their long experience as carriers, are best fitted to accomplish this with the maximum of benefit to the public and the protection of legitimate investment. We do not, however, claim for the railroads any right of monopoly, but merely the privilege of attempting the job without hampering and unsound restrictions or the handicap of discrimination or subsidized competition.

The Pennsylvania Railroad has been actively engaged in the coordination of highway transport with its rail service for the last eight years. We are utilizing motor-trucks, operated under contract, from station to station on the highways to replace local or pedler freight trains and on lines of light traffic, with a large saving of unprofitable train-miles. We now have 49 routes of this character, covering 1770 route-miles daily.

Less-Than-Carload Freight

Between certain large distributing centers we have established a special service for less-than-carload freight, utilizing portable containers constructed so that they can be carried on motor-trucks in the terminal zones between store door and rail head and on specially equipped flat-cars for the rail haul from city to city. This is an interesting illustration of coordinated service and has been quite successful from the viewpoint of revenue. Claims have almost vanished on account of protection given to goods, and the shippers save materially in packing and wrapping.

Success in this field led to further studies having for their object a return to the rails of certain traffic now moving by highway which we believe can be more efficiently handled on the rails. We are satisfied, too, that this can be done not only without detriment to the trucking interests but actually to their advantage.

Coordinated Highway and Rail Service

Competition of trucks with our railroad in line-haul service is practically limited to 250-mile zones, reaching a peak at about 100 miles. Conditions were therefore carefully studied between Philadelphia and New York City, where the distance is about the latter figure and the volume of through trucking very large. Conferences were held with leading truck operators to ascertain what the actual cost was to them of a loaded run between these cities, with 20-ft. truck-bodies. We made careful studies to determine a figure at which we could transport detachable loaded bodies of that length by rail over the same route. We intend to ask authority for the initiation of such a service in cooperation and coordination with truck lines now operating. The trucker will collect and deliver in both cities between the rail stations and the store door of shipper or consignee. We will carry his truck body for him between the cities for one-half of what it costs him to move it over the highway by motor truck. This will allow the trucker to earn more satisfactory profits, bring back remunerative business to the rails and make possible performance of the whole service at less cost to the shipper than at present. Highway transport, rail transport and the public alike will be benefited, this being a happy example of the possibilities that lie in coordinated service.

A somewhat similar service was inaugurated recently between Baltimore and points on the Delmarva Peninsula. Portable motor-truck bodies are carried across Chesapeake Bay on boats and transported by rail to Salisbury, Md., whence they are distributed on truck chassis to various peninsular communities.

Coordination with Motorcoach Service

In the passenger field we have developed extensive coordination with motorcoach service and are broadening these operations wherever conditions seem promising. We have acquired complete ownership of a number of local lines and have made a substantial investment in the Greyhound Lines, which provide our coordinated through service. Motorcoaches are being used to replace unremunerative trains, to act as feeders and to permit the elimination of many local stops by through trains. Our investments in bus transportation are profitable and we expect them to become increasingly so.

To sum up, we believe the sound viewpoint is that highway transport offers the railroads an opportunity to expand their service into new fields and increase the scope of their usefulness. The policies and activities of the Pennsylvania management are based entirely upon that theory.

Trucks Extend St. Louis Markets

A SURVEY completed recently by the Industrial Club of St. Louis reveals that 50 per cent of all less-than-carload freight-traffic originating in St. Louis, Mo., for destinations within a 150-mile radius, is transported by motor-truck lines.

There are 245 motor-truck lines

giving direct overnight express service with store-door delivery to 1317 cities, towns, and villages within a 500-mile radius of St. Louis. Of these, 665 towns in Missouri and 397 towns in Illinois are served by motor-transportation companies operating on regular schedule over designated routes.

Two types of motor-truck service are available to St. Louis shippers. These are the direct or non-stop type of service to distant cities, and the local service with intermittent stops at all communities within a 200-mile radius from St. Louis. Distant cities served by the first type of motor-truck operation include Chicago, Milwaukee, Cleveland, Louisville, Nashville, Memphis, Oklahoma City, Wichita, Kansas City and Davenport. Of these regular truck-lines, 190 concentrate their St. Louis operations in nine union terminals or freight depots in the downtown districts, the remaining 55 having individual headquarters.

Besides the 245 motor-truck lines referred to, the report indicates that there are more than 300 independent trucking companies or individuals engaged in transporting live-stock to packing houses and stockyards of the St. Louis district. Many of these trucks are available for carrying freight, particularly farm supplies and feed, on their round trips.

The survey also noted that there have been many recent developments for the improvement of motor-truck service. One local truck-terminal from which radiate the lines of 41 trucking companies recently published a tariff covering freight rates to 400 communities distributed through six nearby States. These rates include a charge which protects shippers against fire, theft, and all other road contingencies, and also provides for the transmission of c.o.d. shipments at a slight additional charge.—*Highway Spokesman.*

Pacific-Coast Fleet-Maintenance

Recent Special Upkeep Practices of the Southern California Telephone Co. Outlined

TO MAINTAIN that portion of the Bell telephone system's fleet of about 900 vehicles which operate in the Southern California area, the inspector-repairman method is employed. As stated by Thomas H. Mackechnie, of the Southern California Telephone Co., in a recent paper presented before the Southern California Section, his company does not have a centralized overhaul shop. Each of the 17 inspector repairmen is assigned to some particular garage, and it is his responsibility to maintain all of the units housed in that garage.

As this system has worked out, Mr. Mackechnie states, it is found that operations such as valve grinding and brake relining, which do not require highly specialized tool equipment, can be handled satisfactorily by the inspector repairman personally or by the mechanics or garagemen working under him. The company does not believe in major overhauls, as such, continued Mr. Mackechnie, because, if a car has a major overhaul, a number of parts that still retain considerable service are junked. When a major-repair operation is necessary, the vehicle is sent to some outside repair shop.

Inspector-Repairmen's Duties

One outstanding advantage in favor of the inspector-repairman system is that it makes one man in each garage solely responsible for the condition of the equipment in that garage and thereby affords him direct personal contact with the drivers who work out of that garage. Inspector repairmen's duties are to:

(1) Visit, inspect, adjust, check lubrication and make minor repairs to each vehicle periodically, preferably while the driver is available for consultation

(2 Instruct and examine the drivers during the inspections as to the care and operation of the vehicle, safe driving-practices and traffic regulations

(3) Pass on new drivers and instruct regular drivers upon assignment to another vehicle of different design or power equipment

(4) Inspect special equipment, including trailers, during field visits

(5) Arrange for repair work, in addition to roadside repairs, either in company or in commercial repair shops

(6) Inspect major repairs made by commercial repair shops, examine the parts removed and the like, review the charges for such repairs as to fairness; investigate and list satisfactory commercial shops

(7) Supervise repairs to special equipment such as earth borers, winches, pumps, compressors and other power equipment

(8) Aid or secure help for drivers having road breakdowns or accidents which incapacitate the vehicles

(9) When conditions warrant, assist in the investigation of accidents involving motor equipment. Inspect vehicles that have been in accidents, and arrange to have repairs made

(10) Arrange to have vehicles painted, secure painting materials, arrange with the shop and the painter to do the work

(11) Inspect tires removed from service and determine whether to repair them, secure an adjustment from the tire company for them, or junk them

(12) Prepare vehicles for delivery to dealers on trade-ins and arrange for the installation of necessary equipment and the servicing of new vehicles.

Another feature that has been found economical is doing away with the company's own tow car for use in case of emergency road breakdowns and having these breakdowns cared for by the agency or accepted repair shop nearest to the scene of the breakdown. This practice results in minimizing time lost in traveling to the breakdown and driver's lost time as well.

Important Points in Fleet Operation

Mr. Mackechnie listed as important points: Mechanical repairs of all kinds; keeping the necessary records; tire upkeep and all data relating to it; daily service such as supplying gasoline, oil and water; regular service such as washing, cleaning and polishing, maintaining tires and tire inflation; lubricaton; and a periodical general inspection of each vehicle.

In conducting a program of repairs, particular attention must be given to the safety features of the steering system, brakes, lights, horn, oil, bearings and tires. It is possible to be too extravagant, and it is equally possible to neglect necessary expenditures. Some consideration should be given to the age and value of the vehicle and to the kind of service to which it is assigned. In general, the aim should be to do good repair work at a reasonable cost, which requires a certain amount of shop equipment, good tools, skilled mechanics, proper supervision and a fair supply of parts. Tire upkeep deserves considerable attention, and a complete record of tire performance should be maintained. The type and size of tire best adapted to the particular vehicle must be determined, and also how much retreading and repairing can be done economically. Care of the tires is very important, and it is a good practice to check inflation pressures at least once a week.

A definite program should be laid out to take care of washing, polishing and the like. Lubrication is very important and has a direct bearing on the operating cost. The use of a good grade of lubricating oil is profitable. The form used to cover a complete inspection shows every item of importance on a vehicle. These inspections are made as often as possible, and not more than 60 days apart.

Maintenance Facilities Provided

During the last year the company has built three new garages in which has been placed the most modern equipment available for the fast and economical servicing of cars. For tire inflation a stationary compressor is provided from which air at a pressure of 160 lb. per sq. in. is piped to connections along the wall on both sides of the building and to six connections underground through the center part

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News of Section Meetings

(*Concluded from p. 25*)

youth who last year earned a clear claim to local championship in this class, won two of the three outboard races. While a driving rain made visibility a matter of guesswork, he twice raced the course in spurts of speed that enabled him to easily outdistance his rivals. The results of the four events are as follows:

Five-mile race for outboards.—Won by C. Kirkpatrick, Buffalo; second, George Whitney, Buffalo; third, George Sherman, Jamestown; fourth, George Gillig, Buffalo.

Three-mile race.—Won by Francis Brobeil, Buffado; second, Dr. O. O. Hansen, Buffalo; third, George Whitney, Buffalo.

Two-mile race.—Won by Brobeil; second, George Sontag, Buffalo; third, Dr. Hansen, Buffalo.

Runabouts.—Won by Robert Stalling, Buffalo; second, Thomas Gritte, Buffalo; third, Carl Yeager, Buffalo.

In the evening a banquet was held, over which the new Chairman of the Buffalo Section, E. A. Oehler, presided. There were no speeches of any kind, entertainment being furnished by the members of a cast of a local theater.

Canadians Have a Harbor Cruise

THE JUNE meeting of the Canadian Section took the form of a cruise round Toronto Harbor on Wednesday afternoon, June 10. With "wives, friends and sweethearts," according to the notice of invitation, there was a party of about 70, under the tutelage of the charter Chairman, "Bob" Combs, who was observed climbing to various advantageous places in the rigging, with his ever-present motion-picture camera, getting a permanent record of the trip.

General Langton, of the Toronto Harbor Commission, accompanied the party on the steamer, Dalhousie City, and a number of delegates from the Credit Men's Association, then in convention in Toronto, also were present.

The trip was very successful. Bright sunshine favored the 2-hr. cruise round the finest land-locked harbor in the Great Lakes. Life-saving launches circled the steamer, and a fire-fighting tug made rainbows in the sky as it demonstrated its water-throwing capability for the delectation of the delegates.

A Canadian Section golf tournament is being arranged for July, following the very successful one held last year, and indications point to a large turnout.

St. Louisans Inspect Lake and Dam Site

THE Saint Louis Section closed its season with a joint excursion to the new lake and dam at Bagnell, Mo., as guests of the Union Electric Light & Power Co. and the Missouri Pacific Railroad, in company with members of the Engineers Club and the Electrical Board of Trade.

A special train made up of four diners, eight coaches and an entertainment car provided ample accommodations for the 500 men on the trip. On arrival at the property the guests were transferred to flat-cars equipped with benches, and were transported to the dam site. From there a trip on foot up a 1-in-1 gradient to the mess hall was rewarded by an excellent dinner served by men who know how.

Special guides then divided the party into groups for the inspection trip, taking the party through the various interesting sections of the power galleries and other portions of the dam. As a special feature, one of the flood gates, which normally is opened only enough to release sufficient water to maintain the average rate of flow for the stream below the dam, was opened full wide, and the sight of the water rushing down the spillway was appreciated by all. The level of the lake is just reaching its maximum, and the guide said that more water flowed during the time the gate was opened than had ever flowed in a corresponding period.

The lake is the result of blocking the Osage River and forms the largest artificial body of water in the world. It is 125 miles long and has about ten times that much shore line. It is expected to be the vacation spot for hundreds of thousands within easy driving distance. Excellent roads will soon take care of the increasing traffic. An automobile road crosses the dam, so that through traffic need not detour.

The engineers returned that night with the satisfaction that accompanies a day well spent.

A Grievous Error Corrected

IN THE NEWS report of the April 28 meeting of the Washington Section, published in the June issue of the S.A.E. JOURNAL, the company connection of Otto C. Rohde, who presented a very interesting paper on spark-plugs, was erroneously given as "chief engineer of the A. C. Spark Plug Co." As is well known in the industry, Mr. Rohde is chief engineer of the Champion Spark Plug Co. He has held this position with the Champion company ever since he became a member of the Society in 1917, and it is regretted that the mistake was overlooked in the rush of getting the June issue to press.

Diesel-Engine Exhaust-Temperature

IN THE DISCUSSION of E. T. Vincent's paper on Compression-Ignition-Engine Research as printed in the S.A.E. JOURNAL for June, an error occurred in the discussion of F. A. Eysn, appearing on p. 650, which made him say that the exhaust-gas temperature of an engine was 58 deg. fahr.

Mr. Eysn was discussing the possibilities of a two-cycle Diesel engine having a separate air-compressor, for which he estimated a mean effective pressure of 90 lb. per sq. in. at rated full load, an exhaust-gas temperature of 580 deg. fahr. and a weight from 10 to 15 per cent less than that of a gasoline engine of the same power output.

Harry W. Bundy

HARRY W. BUNDY, who was chairman of the board of directors of the Bundy Tubing Co., of Detroit, passed away suddenly on June 2 at his summer home on Beaver Island, Mich. He was widely known in the automotive industry as the founder of the tubing company.

Born in Winona County, Minn., in 1876, Mr. Bundy became general superintendent of the Springfield Drop Forge Co., of Springfield, Mass., in 1900, and from that time until his death was engaged in the metal-working industry, successively as assistant general superintendent of the Wyman & Gordon Co., of Worcester, Mass.; general superintendent of the Atlas Drop Forge Co., of Lansing, Mich.; traveling salesman for the Driggs, Seabury Ordnance Corp., or Sharon, Pa.; factory manager of the Diamond Mfg. Co., of Detroit; department manager with the Motor Products Corp., also of Detroit, and sales agent conducting business for himself.

Subsequent to 1918 Mr. Bundy began experimenting in the manufacture of tubing for automobile gasoline and oil lines. These experiments resulted in the development of machines for the lateral rolling of tubing, and in 1922 Mr. Bundy organized the company which bears his name and is using the machines that resulted from his experiments.

At the time of his election to the Society as an Associate Member in February, 1926, Mr. Bundy was president and general manager of the Bundy Tubing Co., but in 1929 he was elected chairman of the board of the company and was until the time of his death in direct charge of experimental engineering. In January, 1931, he was transferred to Member grade. From 1922, he was continually making experiments and had taken out more than two dozen patents covering material used on automobiles.

William J. Gaffke

FOLLOWING an illness of more than a year, William J. Gaffke died at Buffalo on May 22, after a thyroid operation.

Born at Danzig, Germany, in 1886, Mr. Gaffke came to this Country as a young boy, and after graduating from grammar school studied mechanical engineering at night school in Syracuse, N. Y., for four years. After serving his apprenticeship with the H. H. Franklin Mfg. Co., he became toolmaker and later department foreman with the Pierce-Arrow Motor Car Co., of Buffalo. He was in turn tool engineer, assistant production engineer and mechanical processes engineer. Between 1921 and 1928 Mr. Gaffke was connected with the Off and On Chair Co., the Dunlop Tire & Rubber Co., the American Radiator Co. and the Federal Radio Corp., all of Buffalo. In 1928 he became foreman at the plant of the Houdaille Engineering Co., of the same city.

Mr. Gaffke joined the Society in 1929, as an Associate Member.

Frank M. Burch

A LONG and faithful career in the automobile industry ended with the recent death of Frank M. Burch, quality manager for the H. H. Franklin Mfg. Co. at Syracuse.

Mr. Burch, who was born in Livingston County, Mich., in 1880, started in the industry in 1904 with the Olds Motor Works, of Lansing, Mich., and remained with that company until 1922. He worked in the transmission and axle departments for the first five years, and for the next half decade was engaged on electric wiring and magneto installations in the final assembly department. From 1911 to 1917 he had charge of all body work and wiring of the dash assembly. During the last five years with the Olds company, he had charge of the closed-body trim shop and was division superintendent of closed-body trim and paint work.

Mr. Burch's first change of connection came in 1922, when he became superintendent of plant No. 2 of the Peerless Motor Car Co., in Cleveland, a position which he retained until he transferred his services to the Franklin company, in 1927. For somewhat more than two years he was experimental trim and trim engineer, and in April, 1929, was appointed quality engineer for the company. His duties in this capacity included passing upon the quality of all car parts and finished cars, supervising the test cars and investigating causes of complaints.

Mr. Burch was elected to Associate Grade in the Society in January, 1930.

Arthur Henry Hoffman

AUTOMOTIVE research lost one of its active exponents in Prof. Arthur Henry Hoffman, who died several weeks ago.

Professor Hoffman was widely known for his studies on the subject of air-cleaners, which he dealt with in a number of papers published in THE JOURNAL and TRANSACTIONS from 1924 to 1930. He also studied carburetion in general and oil-filters.

Born Aug. 13, 1873, at Washington, Iowa, Professor Hoffman received degrees from Iowa Wesleyan College and Iowa State College, teaching in the department of physics of the latter institution from 1905 to 1913. He was lecturer on agricultural engineering at the New Jersey State College from 1914 to 1916, and from 1917 to 1919 was assistant professor at the New Mexico State College. In 1919 he joined the faculty of the University of California College of Agriculture at Davis, Calif., with which he remained associated up to the time of his demise.

Professor Hoffman became a Member of the Society in 1927. He was also a member of the American Society of Agricultural Engineers, the American Institute of Electrical Engineers and the Society for the Promotion of Electrical Education.

Frederick Van Z. Lane

ON MAY 8, after a prolonged illness, Frederick Van Z. Lane died in New York City at the age of 50 years.

Mr. Lane was born at Amherst, Mass., in 1881 and studied civil engineering at New York University. Subsequently he held various posts as traffic engineer with municipalities and transportation companies.

After serving as chief transport engineer with the Packard Motor Car Co., of Detroit, and as general maintenance manager for Hare's Motors, Inc., of New York City, he set up in business in 1922 as consulting engineer in the latter city. In 1926 he became vice-president and engineer of the Equitable Coach Co., of New York City. He became a Member of the Society in 1921.

Personal Notes of the Members

Macauley Re-elected N. A. C. C. President

Alvan Macauley, president of the Packard Motor Car Co., and Affiliate Representative of the company in the Society, was reelected president of the National Automobile Chamber of Commerce at the annual meeting of the Chamber in June. Other members of the Society elected to office are A. R. Erskine, president of the Studebaker Corp., and A. J. Brosseau, president of the International Motor Co., reelected vice-presidents; Roy D. Chapin, president of the Hudson Motor Car Co.; Alfred P. Sloan, Jr., president of the General Motors Corp.; Charles D. Hastings, chairman of the board of directors of the Hupp Motor Car Co.; Walter P. Chrysler, president of the Chrysler Corp.; E. L. Cord, president of the Auburn Automobile Co.; and William E. Metzger, vice-president of the Federal Motor Truck Co., reelected to the board of directors of the N.A.C.C.; and Alfred Reeves, reelected general manager.

The Chamber voted to continue cooperating with the American Petroleum Institute and the S.A.E. in the cooperative fuel-research program which is being carried out at the Bureau of Standards.

Deeds Dedicates Flying-Field

At the opening and dedication of Rentschler Field, at East Hartford, Conn., on May 24, Col. Edward A. Deeds was the first speaker in the dedication ceremony. The dedication was followed by a luncheon given by the Hartford Chamber of Commerce to welcome to Hartford the fliers of the Army Air Corps, which was using the new flying-field as one of its bases for operations over the New England States. The field is owned by the United Airports of Connecticut, a subsidiary of the United Aircraft & Transport Corp., and is located directly behind the factories of the Pratt & Whitney Aircraft Co. and the Chance Vought Corp. in East Hartford. It contains 165 acres of grassy land, has two large hangars and is provided with uptodate equipment.

Upson Gets Honorary Degree

The honorary degree of Aeronautic Engineer was conferred upon Ralph H. Upson at the 59th annual commencement of Stevens Institute of Technology at Hoboken, N. J., on June 6, in recognition of his achievements as designer and builder of the experimental metal-clad airship ZMC-2. Mr. Upson was graduated from the Institute in 1910. After the exercises, a demonstration of the Autogiro in take-off, flight and landing was given by Pilot F. W. Soule, who explained the principle of operation and answered questions. Students of the Institute then gave an exhibition of gliders that they had assembled.

Metzger Speaks on Accidents

At the annual convention of the American Automobile Association at West Baden, Ind., the first week in June, William E. Metzger, vice-president of the Federal Motor Truck Co., of Detroit, and chairman of the executive committee of the National Conference on Street and Highway Safety and chairman of the A.A.A. traffic and safety committee, stated that definite progress has been made in bringing uniformity into the basic motor-vehicle laws of the various States, 30 States having enacted important provisions of the Uniform Motor-Vehicle Code. Grade-crossing accidents declined from 5975 in 1929 to 4853 in 1930, or 23 per cent. The most favorable trend in motor-vehicle accidents, he said, was the reduction of fatalities and injuries to children, largely due to the work of 200,000 boys enrolled in safety patrols and to educational work in the form of safety lessons and posters among more than 4,000,000 school children. Examination of drivers as a prerequisite to securing operators' licenses is required in 15 States and the District of Columbia.

Appointed Copeland Vice-Presidents

Copeland Products, Inc., of Mount Clemens, Mich., has announced the appointment of John R. Replogle as vice-president in charge of engineering and Edward Hughes as vice-president in charge of manufacturing.

Mr. Replogle is a pioneer in the electric-refrigeration industry and is credited with perfecting many of the parts used in electric-refrigeration machinery. In 1919 he was made chief engineer of the Frigidaire; later he was chief engineer of the Nizer Corp., and subsequently was connected with the Kelvinator Corp.

Mr. Hughes had been factory manager for Copeland Products for the last two years. Prior to that time he had served on the engineering board of the Detroit Aircraft Corp. for three and a half years, being in charge of production. He had charge of construction of the ZMC-2, the first all-metal airship, and of the building of the mooring mast at the Ford Airport.

Appointed Manager of Engineering at Westinghouse Plant

John M. Lessels, formerly manager of the mechanics division of the Westinghouse Research Laboratories at the East Pittsburgh, Pa., plant of the Westinghouse Electric & Mfg. Co., has been appointed manager of engineering in the South Philadelphia works of the company. He entered the Westinghouse organization in 1920 and became associated with the research department two years later. Before coming to the United States, Mr. Lessels had been aeronautic-engine inspector for the British War Office, assistant manager of the aeronautic-engine department for Armstrong-Whitworth, and special engineer to the works manager for Rolls-Royce in England. He is a member of the Institution of Mechanical Engineers and the Iron and Steel Institute, of England; and the American Society for Testing Materials, as well as the S.A.E.

H. C. Blake is now serving the Publis Utilities Commission of Ohio, having given up his position as assistant to the president of the Nicholas-Beazley Airplane Co., Inc., of Marshall, Mo.

Ray W. Brown has been employed by the Curtiss-Wright Airplane Co., of Robertson, Mo., as regional sales manager. He was previously engaged in similar work along aviation lines for the Shell Petroleum Corp., of Chicago.

James T. Bugbee has been engaged by the Texas Co., of New York City, as a mechanical engineer, engaged in research. He previously served the Tillotson Mfg. Co., of Toledo, Ohio, as an experimental engineer.

L. P. Croset has terminated his services as chief engineer in the Diesel department of Aveling & Porter, Ltd., of Kent, England, and is now serving the Sentinel Waggon Works, Ltd., of Shrewsbury, England, as Diesel engineer.

Emile Deletaille, a Foreign Member of the Society, has resigned his position as service manager of the Fabrique Nationale d' Armes de Guerre, at Herstal (Liége), Belgium, and is now manager of the Etablissements Blavier in Vilvorde, Belgium.

Arthur W. Einstein, formerly merchandise man for A. Polsky Co., of Akron, Ohio, is now serving R. H. Macy & Co., Inc., of New York City.

Warren F. Farrager is now employed as a research chemist, head of the division of light products for the Vacuum Oil Co., at Paulsboro, N. J. He previ-

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Applicants for Membership

The applications for membership received between May 16 and June 16, 1931, are listed below. The members of the Society are urged to send any pertinent information with regard to those listed which the Council should have for consideration prior to their election. It is requested that such communications from members be sent promptly.

BAXTER, H. X., vice-president, J. H. Baxter & Co. & Horace X. Baxter Steamship Co., *San Francisco.*

BERRY, BYRON CONRADE, manager, B. C. Berry & Co., *Toronto, Ont., Canada.*

BISHOP, CHARLES B., junior engineer, Bureau of Standards, *City of Washington.*

BOOTS, EDMUND R., manager, automotive division and director, American Gas Accumulator Co., *New York City.*

BOUIS, C. M., salesman, The White Co., *Pittsburgh.*

BREWER, WILLIAM C., owner, Brewer's Automotive Specialized Service, *Galt, Ont., Canada.*

BRINK, ERNEST HAROLD, instructor in mechanical engineering, Lehigh University, *Bethlehem, Pa.*

COLIN, PHILIP GORDON, supervisor of automotive laboratory, Tide Water Oil Co., *Bayonne, N. J.*

COOPER, CYRIL, president and general manager, Windsor-Chatham-London Coach Lines, Ltd., *East Windsor, Ont., Canada.*

CRANE, CARL J., first lieutenant, Air Corps, United States Army, Brooks Field, *San Antonio, Texas.*

CRICKMER, C. S., chief engineer, The Guiberson Corp., *Dallas, Texas.*

DAMMINGA, C. J., chief engineer, Fitz-John Mfg. Co., *Muskegon, Mich.*

DAVIES, J. H., mechanical superintendent, B. C. Motor Transportation, *Vancouver, B. C., Canada.*

DEPEW, CHESTER C., assistant research engineer, Aeromarine Plane & Motor Co., *Keyport, N. J.*

DRAKE, JOSEPH S., motor-vehicle supervisor, Sinclair Refining Co., *New York City.*

DUCKWORTH, RALPH J., layout draftsman, Reo Motor Car Co., *Lansing, Mich.*

DUNCKEL, RALPH L., purchasing engineer, Amtorg Trading Corp., *New York City.*

ECKHOFF, GUNNAR, aircraft-engine designer, Aircraft & Industrial Motors Corp., *Paterson, N. J.*

GIERS, ERNEST WILLIAM, foreman, road test at General Motors Proving Grounds, Oakland Motor Car., *Pontiac, Mich.*

GILL, JOHN J. E., service fieldman, General Motors South African, Ltd., *Port Elizabeth, South Africa.*

GREGGS, CLARENCE ROY, owner, Roy Greggs Motor Co., *Vancouver, B. C., Canada.*

HALFORD, FRANK BERNARD, designer, aircraft and automobile engines, Frank B. Halford, *London, W. 1, England.*

KONO, YUKIO, owner and manager, service and repair, 407 12th Ave., *Seattle, Wash.*

LENTZ, WILLIAM G., proprietor, Universal Auto Body & Fender Co., *Cincinnati.*

LEONARD, SIMPSON C., JR., secretary and treasurer, Michigan Leather Packing Co., Inc., *Detroit.*

MARBACH, E. R., secretary, engineer, Whiteway Stamping Co., *Cleveland.*

MARTENS, CHARLES H., aeronautical and development engineer, Firestone Tire & Rubber Co., *Akron, Ohio.*

MCCOY, JAMES REYNOLDS, automotive engineer, Gulf Refining Co., *New York City.*

MYHRE, W., assistant service manager, General Motors International A/S, *Copenhagen, Denmark.*

MYRANS, SAMUEL EWIN, general manager, Wilmot-Breeden, Ltd., Eastern Works, *Birmingham, England.*

NEW JERSEY ZINC CO., INC., *New York City.*

PARKER, HARRY P., assistant general manager, L. A. Young Industries of Canada, *Windsor, Ont., Canada.*

PAXTON, SHERMAN L., garage superintendent, Standard Oil Co. of N. J., *Charlotte, N. C.*

OLIVER, ALBERT VERE, chief engineer, De Lavaud Freewheel Differential, Ltd., The Vale Acton, *London, England.*

OTTAWAY, ERIC CARLTON, assistant experimental engineer, London General Omnibus Co., *London, England.*

PILE, J. HOWARD, editor, Chek-Chart Corp., *Chicago.*

RAMBLER, RALPH CASSELL, R. D. 1, *Linglestown, Pa.*

RICE, CLARENCE W., sales manager, El Dorado Refining Co., *El Dorado, Kan.*

SAUNDERS, WILLIAM H., president, International Lubricant Corp., *New Orleans.*

STEPHENS, CURTIS G., inspector, Glenn L. Martin Co., *Baltimore.*

STRADLING, DANNA J., motor-vehicle inspector, Standard Oil Co. of N. J., *Richmond, Va.*

WORK, BOYD H., sales engineer, The Carborundum Co., *Niagara Falls, N. Y.*

WUNSCH, HARRY, mechanical engineer, Silent Hoist Winch & Crane Co., *Brooklyn, N. Y.*

ZIMMERMANN, LUKAS, chassis designer, Chrysler Motor Corp., *Detroit.*

Transportation Engineering

(*Concluded from p. 99*)

of the building. The wall connections will serve five vehicles each. Those in the center serve eight vehicles each, as the vehicles are parked on both sides of these connections. All vehicles can thus be served with a 30-ft. hose. This piping of air is highly economical and enables one man to inflate double the number of tires as compared with using a portable compressor.

The use of two or three driveways as wash racks in the three new garages does away with driving each vehicle to some specific place that is used for a wash rack only and saves time. The driveways extend the full length of the building and are wide enough to permit washing the vehicles after pulling them out from the parking line.

Along the inside of driveways and on the walls, the high-pressure water-system piping has convenient outlets through the floor and along the wall. The outlets are spaced the same as are the air-pressure connections. The water for high-pressure delivery originates in a heater room in one end of the building. A battery of two automatic heaters and a high-pressure rotary-type car-washing machine are installed. The hot water from the heaters is mixed with the cold water at the car-washing machine, the temperature being regulated by the operator, who uses a thermometer.

When washing cars, the operator drives the car forward out of its stall into the driveway and applies both brakes so as to prevent water from getting into the brake-lining, holding the brakes in position by using a lever and a wooden block. He then goes to the boiler room and starts the high-pressure washing-machine, adjusts it to deliver the desired pressure, regulates the heat of the water to the desired degree, attaches the high-pressure hose to a connection in the floor or wall, and is then ready to wash the vehicle. A tag stating that the vehicle has just been washed is placed on the steering-wheel to assist the driver and call his attention to the fact that his brakes may have become wet and that he should apply them and assure himself that they are in working order.

Mr. Mackechnie, in concluding, stated that the company has found that the building of suitably equipped garages has become a highly specialized accessory very necessary to economical and successful fleet maintenance.

Notes and Reviews

AIRCRAFT

A Method of Flight Measurement of Spins. By Hartley A. Soulé and Nathan F. Scudder. Report No. 377. Published by the National Advisory Committee for Aeronautics, City of Washington, 1931; 18 pp., illustrated. [A-1]

A method is described involving the use of recording turn-meters and accelerometers and a sensitive altimeter, by means of which all of the physical quantities necessary for the complete determination of the flight path, motion, altitude, forces and couples of a fully developed spin can be obtained in flight. Data are given for several spins of two training-type airplanes which indicate that the accuracy of the results obtained with the method is satisfactory.

The method was developed by the National Advisory Committee for Aeronautics at Langley Field, Va., as a part of a general study of the phenomenon of spinning. It is now being used in an investigation to determine how the spinning characteristics of several airplanes are affected by various changes in their inertia and geometric characteristics. A study is being made to extend the method to include measurements during entry and recovery from a spin as well as during the fully developed spin.

Rolling Moments Due to Rolling and Yaw for Four Wing-Models in Rotation. By Montgomery Knight and Carl J. Wenzinger. Report No. 379. Published by the National Advisory Committee for Aeronautics, City of Washington, 1931; 27 pp., illustrated. [A-1]

This report presents the results of a series of autorotation and torque tests on four different rotating wing-systems at various rates of roll and at several angles of yaw. The investigation covered an angle-of-attack range up to 90 deg. and angles of yaw of 0, 5, 10 and 20 deg. The tests were made in the 5-ft., closed-throat atmospheric wind-tunnel of the National Advisory Committee for Aeronautics. The object of the tests was primarily to determine the effects of various angles of yaw on the rolling moments of the rotating wings up to large angles of attack.

Pressure Distribution Over the Fuselage of a PW-9 Pursuit Airplane in Flight. By Richard V. Rhode and Eugene E. Lundquist. Report No. 380. Published by the National Advisory Committee for Aeronautics, City of Washington, 1931; 29 pp., illustrated. [A-1]

This report presents the results obtained from pressure distribution on the fuselage of a PW-9 pursuit airplane in a number of conditions of flight. The investigation was made to determine the contribution of the fuselage to the total lift in conditions considered critical for the wing structure, and also to ascertain whether the fuselage loads acting simultaneously with the maximum tail-loads were of such a character as to be of concern with respect to the structural design of other parts of the airplane. The tests were conducted by the National Advisory Committee for Aeronautics at Langley Field, Va., in the spring of 1929.

The results show that the contribution of the fuselage toward the total lift is small on this airplane, ranging from slightly less than 3 per cent at the lower angles of attack to about 4 per cent at the higher angles, which approximately compensates for the portion of the wing area replaced by the fuselage. Aerodynamic loads on the fuselage are, in general, unimportant from the structural viewpoint, and in most cases are of such character that, if neglected, a conservative design results. In spins, aerodynamic forces on the fuselage produce diving moments of appreciable magnitude and yawing moments of small magnitude but opposing the rotation of the airplane.

An Integrating Manometer for Use in Wind-Tunnel Pressure-Distribution Measurements. By Richard W. Noyes. Technical Note No. 377; 6 pp., 3 figs. [A-1]

Comparison of Weights of 17ST and Steel Tubular Structural Members Used in Aircraft Construction. By E. C. Hartmann. Technical Note No. 378; 17 pp. 5 figs. [A-1]

The Pressure Distribution Over a Semicircular Wing-Tip on a Biplane in Flight. By Richard V. Rhode and Eugene E. Lundquist. Technical Note No. 379; 14 pp., 5 figs. [A-1]

The foregoing three Technical Notes were issued during May, 1931, by the National Advisory Committee for Aeronautics, City of Washington.

Combined Pitching and Yawing Motion of Airplanes. By A. v. Baranoff and L. Hopf. Translated from *Luftfahrtforschung*, vol. 3, no. 2, March 20, 1929; Verlag von R. Oldenbourg, München und Berlin. Technical Memorandum No. 620; 29 pp., 38 figs. [A-1]

The Take-Off of Seaplanes Based on a New Hydrodynamic Reduction Theory. By Paul Schröder. Translated from *Zeitschrift für Flugtechnik und Motorluftschiffahrt*, vol. 22, no. 1, Jan. 14, 1931; Verlag von R. Oldenbourg, München und Berlin. Technical Memorandum No. 621; 8 pp., 7 figs. [A-1]

Landing of Seaplanes. By Herbert Wagner. Translated from *Zeitschrift für Flugtechnik und Motorluftschiffahrt* vol. 22 no. 1, Jan. 14, 1931; Verlag von R. Oldenbourg, München und Berlin. Technical Memorandum No. 622; 15 pp., 18 figs. [A-1]

Eleventh Rhön Soaring-Flight Contest, 1930. By Walter Georgii. Translated from *Zeitschrift für Flugtechnik und Motorluftschiffahrt*, vol. 22, no. 5 March 14, 1931; Verlag von R. Oldenbourg, München und Berlin. Technical Memorandum No. 623; 16 pp., 9 figs. [A-1]

The foregoing four Technical Memoranda were issued during May and June, 1931, by the National Advisory Committee for Aeronautics, City of Washington.

Dynamic Test of Long-Stroke Oleo Strut with Compensating Valve. Air Corps Technical Report No. 3352; 3 pp., 2 figs. [A-1]

The foregoing Air Corps Information

(*Continued on next left-hand page*)

These items, which are prepared by the Research Department, give brief descriptions of technical books and articles on automotive subjects. As a rule, no attempt is made to give an exhaustive review, the purpose being to indicate what of special interest to the automotive industry has been published.

The letters and numbers in brackets following the titles classify the articles into the following divisions and subdivisions: *Divisions*—A, Aircraft; B, Body; C, Chassis Parts; D, Education; E, Engines; F, Highways; G, Material; H, Miscellaneous; I, Motorboat; J, Motorcoach; K, Motor-Truck; L, Passenger Car; M, Tractor. *Subdivisions*—1, Design and Research; 2, Maintenance and Service; 3. Miscellaneous; 4, Operation; 5, Production; 6, Sales.

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PARISH FRAMES and STAMPINGS — PARISH PRESSED STEEL CO. READING PENNA.

Notes and Reviews

Continued

Circular was published by the Chief of the Air Corps, City of Washington, April 1, 1931.

Ein Beitrag zur Lösung des Problems der Verkürzung von Start und Landung bei Flugzeugen. By Rudolf Jaeschke. Published in *Zeitschrift für Flugtechnik und Motorluftschiffahrt*, April 28, 1931, p. 221. [A-1]

After stressing the importance of shorter take-off and landing runs for the more economic and widespread use of aerial travel, the author points out the elements of aircraft design involved in achieving this end. He refers to the proposal made by Professor Schmeidler in March, 1927, at the technical university at Breslau for the construction of a variable-area wing, and, after pointing out the two defects usually involved in such structures, that is, too great weight and poor aerodynamic characteristics under certain flight conditions, he outlines aerodynamic and constructional features necessary to be incorporated in such wings.

An experimental airplane built at the Breslau university incorporating variable-area wings is next described. The optimum design features for take-off and landing are determined and suggestions made for improvements in the experimental airplane. Finally, the possibility of a trailer airplane with controllable wing-surface is discussed.

Über Schwimmer und Schwimmerversuche. By Friedrich Seewald. Published in *Zeitschrift für Flugtechnik und Motorluftschiffahrt*, May 15, 1931, p. 265. [A-1]

When the German Institute for Aeronautical Research first undertook the study of pontoons, one of its first tasks was to attempt to reconcile the conflicting results of previous research carried on by other investigators. The present article summarizes the study made to ascertain the causes of such differences and presents the results obtained up to the present insofar as these represent findings of general interest and significance. Two problems are principally dealt with, the resistance of pontoons and the impact loading at take-off and landing.

Specifically, the topics dealt with are: pontoon resistance at take-off and its determination by model tests; influence on resistance of the trimming angle; influence of this factor on the design of seaplanes and on model tests; possibility of so carrying out pontoon research that it shall be applicable generally; impact loading on landing; the course of impact forces and stresses; influence of elasticity, keel and condition of water surface on impacts; measurement of impact forces and suggestions for further research.

Handbook of Aeronautics. Published under authority of the Council of the Royal Aeronautical Society, with which is incorporated the Institution of Aeronautical Engineers, by Gale & Polden, Ltd., London, 1931; 702 pp., illustrated. Price, 25 shillings. [A-3]

The purpose of this handbook is to collect, in as accurate and authoritative a form as possible, information of everyday use to the designer and constructor of aircraft and the aeronautic engineer.

A glance at the list of names comprising the editorial staff and contributors is sufficient assurance of the quality of the volume. The work has been compiled under the technical editorship of the secretary, Capt. J. Laurence Pritchard of the Royal Aeronautical Society, whose council has approved the publication.

Chapters included are: Materials, Performance, Aerodynamics, Design and Construction, Airscrews, Engines, Air Survey and Photography, Instruments and Navigation, Wireless, Meteorology, Airship Design, and General Tables.

(*Continued on next left-hand page*)

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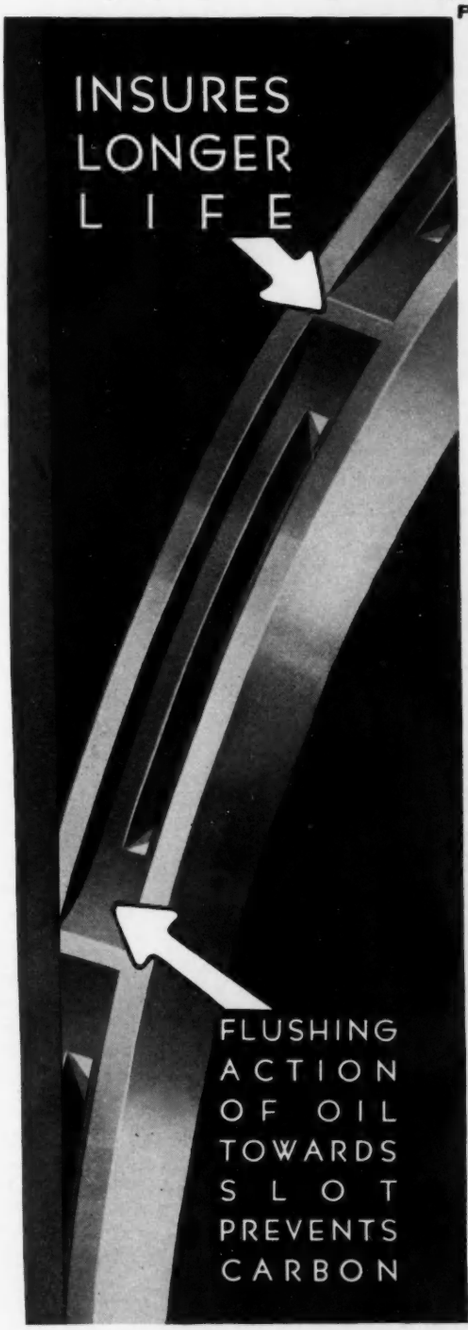

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Notes and Reviews

Continued

The Story of the Airship. By Hugh Allen. Published by the Goodyear Tire & Rubber Co., Akron, Ohio; seventh edition, 1931; 84 pp. illustrated. [A-3]

This work, written in a popular style and outlining the development and present practice in airship building, has been published annually since 1925 chiefly as a convenient reference book for students.

Chapters dealing with the construction of The Akron, the new Navy airship now nearing completion, are of special interest at this time, and the book is generously illustrated with reproductions of good photographs. An appendix contains such useful information as size of airship docks throughout the world, height of the world's mooring masts, records made in national and international balloon races, and a brief bibliography on airships.

CHASSIS PARTS

A Propos du Châssis Naturellement Indéformable. By N. Causan. Published in *La Vie Automobile*, Feb. 10, 1931, p. 48. [C-1]

Inherent and absolute protection against deformation is the claim made for the chassis described in this article. The frame proper is conventional in design, consisting of two side-rails and two cross-members, but it is fixed at four points to a diamond-shaped sub-frame. The fore and aft points of the sub-frame are fastened to the center points of the cross-frame members by ball-and-socket joints. The side points of the sub-frame are bolted to the side-rails of the main frame at points midway between the cross-members. The sub-frame carries the four suspension springs, each supported at one end at the ball-and-socket joint, with the other end so placed on the axle that the spring forms, in direction, a prolongation of one of the sub-frame members.

So designed, the chassis is asserted to be proof against buckling and to be able to dispense with exceptionally rigid and heavy frame members. The merits of the chassis are discussed under the headings of roadability, suspension, weight distribution, lateral stability, weight, cost of fabrication and stresses.

Méthode de Calcul et Principe de Normalisation des Arbres Cannelés. By M. Berger. Published in the *Journal de la Société des Ingénieurs de l'Automobile*, March, 1931, pp. 1298 and 1320. [C-1]

After having studied the three existing national standards on clutch-disc sizes—the British, German and American—the French standards bureau adopted the German standard, as it was expressed in the metric system. This action was guided by the hope that it would prove a distinct impetus to the adoption of an international metric standard. Most French manufacturers have adhered to the new standard in their design of this year's models, thus cutting down the number of clutch sizes from about 150 to about 20.

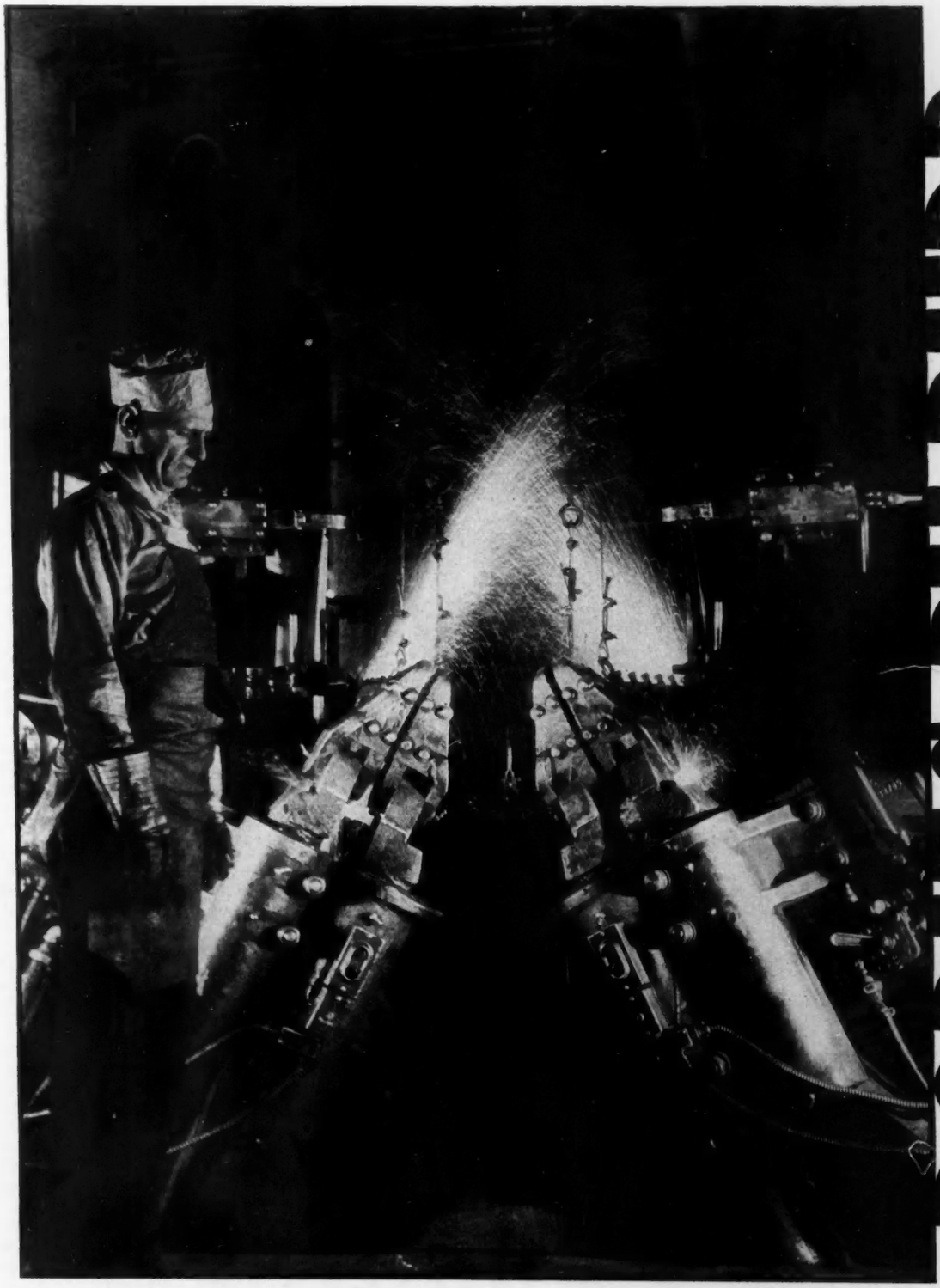
Splined shafts, the part discussed in the present article, are said to have presented one of the most difficult of the 144 subjects for standardization considered by the French standards bureau. The development of the standard now under consideration as the proposed international standard is here traced.

A study made of existing British, German, Italian and American national standards and of the 3000 different models actually in production was not helpful, as it did not reveal any uniformity among the different countries, any logical principle of standardization or any achievement of the desired goal, which was reduction of the number of sizes to the minimum compatible with the conditions of usage. The aim of the French study was to decrease the number of models, not only of splined shafts, but of the machine-tool equipment used in their production.

A theoretical study, the principles of which are here set

(*Continued on next left-hand page*)

Where there are no joints in a body, there can be no squeaks, no rattles. In the one-piece body, Budd eliminates joints by the extensive use of flash welding—makes bodies of eight major parts, flash welded into a single piece. This construction, originated by Budd engineers, makes possible a degree of silence unattainable in any other type of body.



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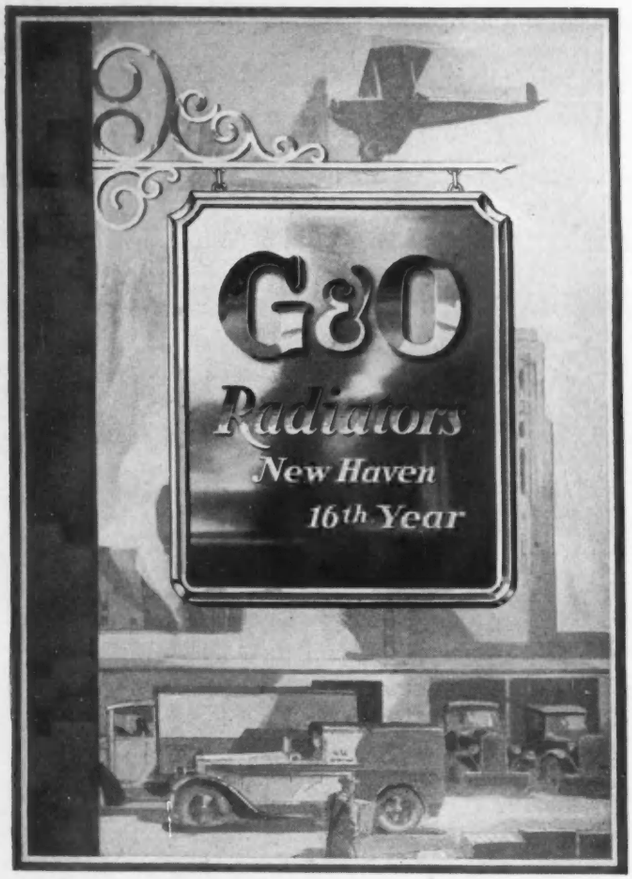

UTMOST SIMPLICITY

There are only four parts within the socket of the Thompson Eccentric Tie Rod.

Thompson Eccentric Tie Rods

Notes and Reviews

Continued

forth, was next made, and the results were found to agree, with one or two exceptions, with the Italian standard. The standard so developed won the support of the French industry and of the Italian and Belgian delegation to the international congress on automotive standardization, and is now the basis of discussion as an international standard.

Contribution a l'Etude des Transmissions Automatiques. By G. Fleischel. Published in *La Technique Automobile et Aérienne*, 2nd quarter 1931, p. 33. **[C-1]**

Under the heading of automatic transmissions the author considers only those mechanisms which, used in conjunction with a gearbox, relieve the driver of the necessity of gear-shifting. Such devices, he points out, must perform two functions: make the decision as to when the shift should be made and perform the operation of shifting. The problems involved in developing a mechanism capable of assuming the second duty are said to be simple and to have been solved in the design of a number of devices, among which the Cotal magnetic planetary transmission is favorably mentioned.

A theoretical study is made of the conditions under which a gearshift is necessary. The factors to be considered are the speed of the engine and the vehicle and the load on the engine. The influence of speed, the author states, can best be translated into an actuating force by a centrifugal regulator, and that of engine load by manifold depression. He then describes an automatic clutch or, as it is termed, an "unlatcher," based on these principles, by which the first function of an automatic transmission can be assumed. In summing up the advantages of automatic transmissions, the author lays least emphasis on the relief of the driver; far more important are said to be the many respects in which vehicle performance is improved.

ENGINES

Automobile and Aircraft Engines. By Arthur W. Judge. Published by Isaac Pitman & Sons, New York City and London; second edition, 1931; 845 pp., 448 figs. Price, $10. **[E-1]**

Since the last previous edition of this book was published, important progress has been made in both the theoretical and experimental development of the high-speed internal-combustion engine. Notable among the advances is the development of the high-speed compression-ignition engine, a fairly full account of which is given in the present volume.

The author considers combustion; thermodynamics of the internal-combustion engine; ideal and real efficiencies; conduction, radiation and cooling effects; temperatures; pressures; volumetric efficiency; power measurement; the stratified-charge engine; altitude effects; supercharging; detonation; high-speed compression-ignition engines; engine balance; fuels; and the mechanics of the high-speed internal-combustion engine.

Practical Marine Diesel Engineering. By Louis R. Ford. Published by the Simmons-Boardman Publishing Co., New York City; second edition, 1931; 758 pp., illustrated. Price, $7. **[E-1]**

This treatise discusses the construction and operation of the marine Diesel engine from the point of view of the practical engineer. The rapid strides that have been made in the development of the Diesel engine since the first edition was published in 1925 made it necessary to entirely rewrite the major portion of the book and insert additional matter. The section dealing with engine parts has been considerably enlarged to include important new developments in design practice.

The section devoted to descriptions of engines of various makes proved of such interest as to warrant considerable enlargement, the author states, hence virtually every type

(*Continued on next left-hand page*)

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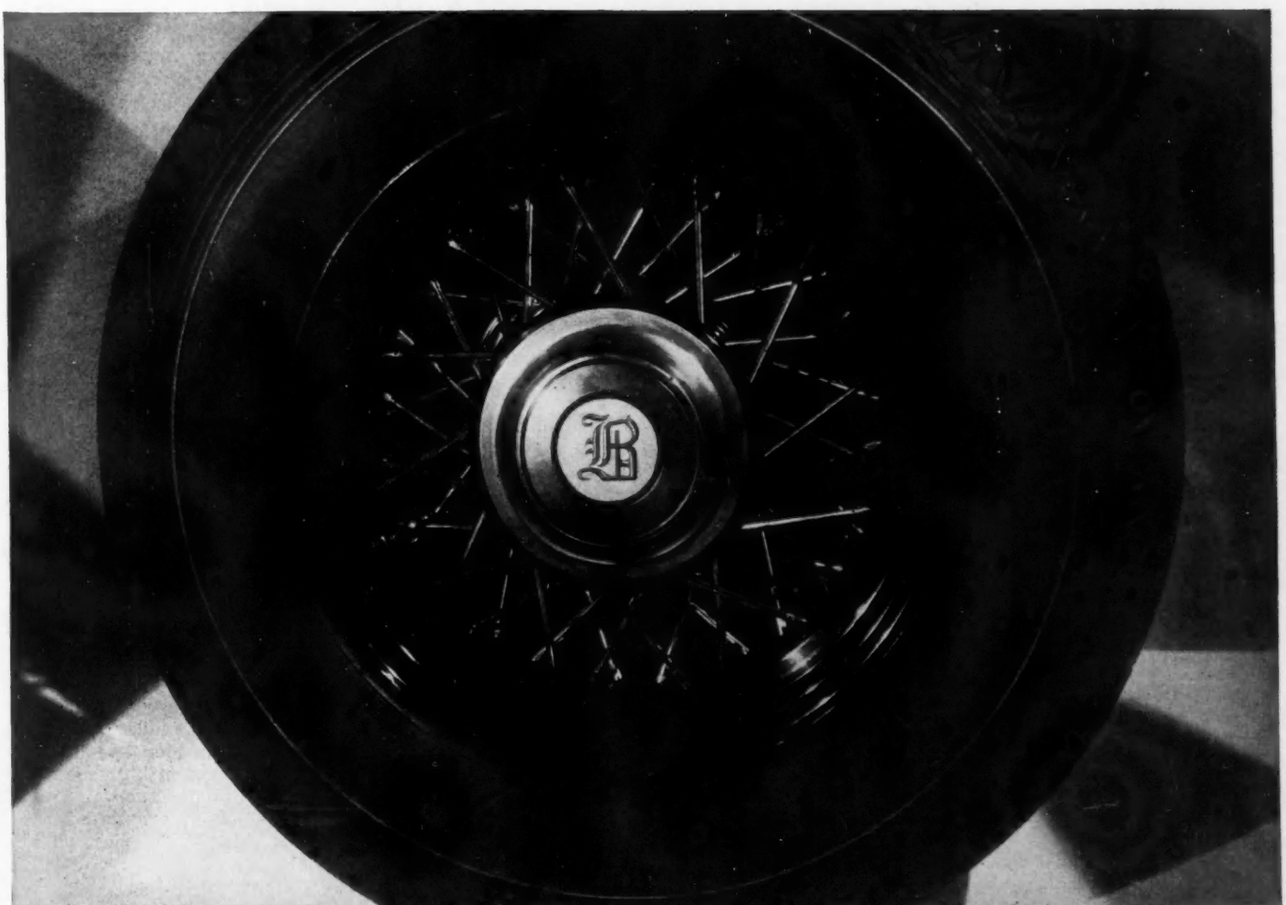

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Notes and Reviews

Continued

of marine Diesel engine built today is included. The descriptions are specific and liberally illustrated with sketches and sectional drawings.

The double-acting engine and the possibilities of the four-cycle single-acting engine using pressure charging are the subjects of two new chapters; and chapters on shipyard repair and licensing of motorship engineers have also been added.

American Diesel Engines. By L. H. Morrison. Published by the McGraw-Hill Book Co., Inc., New York City and London, 1931; 597 pp., illustrated. Price, $5. [E-1]

This book is concerned chiefly with the large powerplant type of Diesel engine, although some space is given to a consideration of aircraft Diesels and Diesel-electric locomotives.

The author discusses the early history of the Diesel engine in the United States, the economics of Diesel power, air-injection and airless-injection engines, oil-engine installation, frames, main bearings and crankshafts, pistons and piston-pins, connecting-rods, cylinders and cylinder-heads, valves, fuel-pumps, mechanical-injection fuel valves and pumps, lubrication, cooling systems, Diesel fuel oils, air-compression systems, engine output, and operating procedure.

Engine Performance at High Compression-Ratios. Engineering Research Circular No. 6. By H. E. Zuck. Published by the Department of Engineering Research, University of Michigan, Ann Arbor, Mich., March, 1931; 33 pp. [E-1]

This circular gives the results of a research in which the effect of compression ratio, mixture ratio and spark timing on the tendency of a standard motor fuel to detonate and the power developed with such a fuel are studied. The data were taken on an N. A. C. A. Universal Test Engine at a constant speed and are given in five sets of curves using as ordinates the several variables named. They show that the power increases with an increase in compression ratio after detonation is encountered but at a decreasing rate until, with severe knocking, a maximum is reached, after which the power decreases at an accelerated rate with further increase in compression. The most significant presentation of the results is in curves that show that, for a given fuel, practically no change occurs in the power developed over a range of compression ratios provided the spark is adjusted to give the same intensity of knock.

Flugmotoren in Leicht und Schweröl bauart. By W. Thoelz and W. Haeder. Published by Richard Carl Schmidt & Co., Berlin, Germany; 352 pp.; 237 illustrations. [E-1]

This handbook on aircraft engines is written for the practical student, designer and builder. Extended theoretical discussion is omitted, the book being confined to a presentation of the fundamentals involved in aircraft-engine construction as indicated by experience in service and an evaluation of various structural methods.

The gasoline and the heavy-oil engine are considered in conjunction with each other so that the reader can see how the parts for the latter may be based on the design of the former, with due consideration for the higher pressures to be encountered. All types of construction could not be considered, but the authors have formulated the fundamental data given with the idea that they could serve as a basis for the design of different types.

In the first part of the book the more abstract aspects of the subject, such as fuels, combustion processes, working diagrams, efficiency, heat balance and supercharging, are discussed, while the second section deals with the design of specific parts, crankshafts, cylinders, water-jackets, pistons, valves, connecting-rods and so forth.

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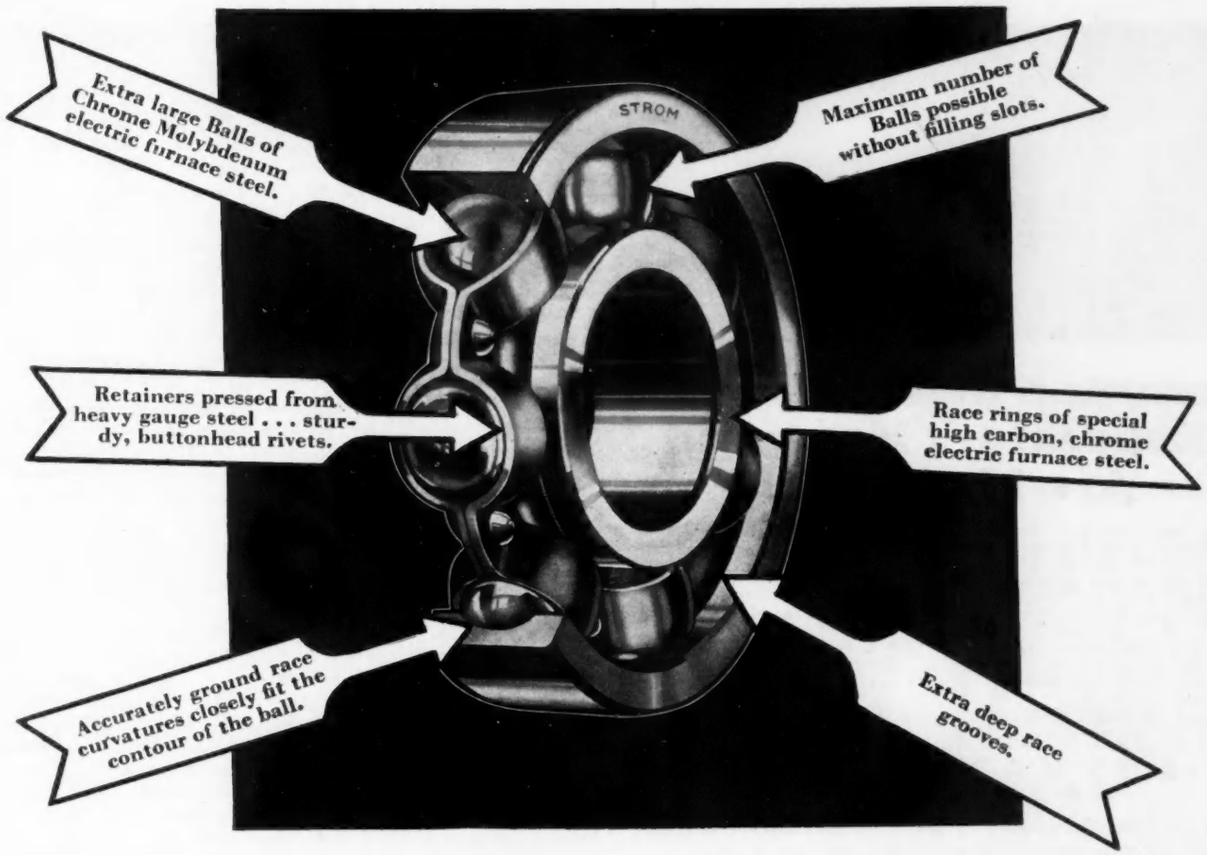
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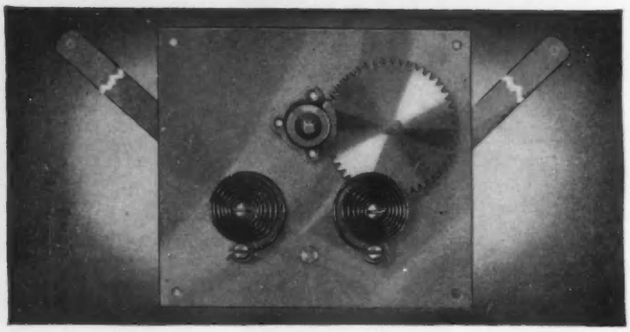

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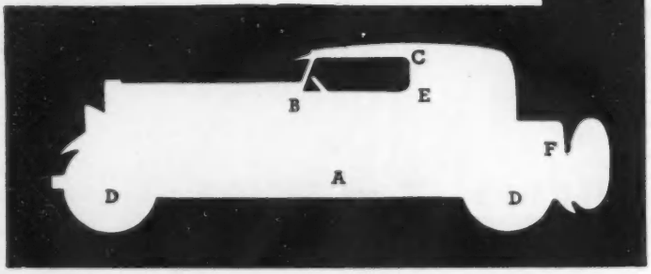

Notes and Reviews

Continued

Untersuchung von Automobilkühlern. By Karl Dehn. Published by Verlag des Vereines Deutscher Ingenieure, Berlin, Germany; 20 pp.; 28 illustrations. [E-1]

The Society of German Engineers sponsored the research on automobile radiators herein described. It dealt only with the tubular type of radiator, in which the water flows in closed tubes while the air passes around them, including staggered and straight formations and finned and finless types. An experimental investigation was made, and basic data for the purposes of design and calculation were developed.

The plan followed was to extend previous experiments on heat transfer in closely spaced tubes to models with larger distances between tubes. Even with comparatively large distances no considerable change in heat transfer was noted. The heat transmission of the radiators was determined from the rise of temperature of the surrounding air by tests and computation. In radiators having fins, allowance was made for the efficiency of the cooling surface not touched by water and the influence of the surfaces not directly cooled by air.

The results obtained show that the indirect radiating surface of the fins is not much inferior in its cooling effect to that cooled directly by water. A considerable temperature drop takes place at the root of the fins, so that an excessive increase in the indirect-cooling surfaces would serve no good purpose. The heat-conductive capacity of the tubes themselves is of no large importance.

The degree of resistance to air-flow was determined and the pressure drop calculated therefrom. Measurement of air resistance showed that the resistance caused by radiators at ordinary car-speeds is nearly insignificant.

MATERIAL

Influence of Stress on Corrosion. By D. J. McAdam, Jr. Paper to be presented before the American Institute of Mining and Metallurgical Engineers, Boston, September, 1931. [G-1]

Mr. McAdam's earlier reports on this subject have been reviewed in these columns from time to time. The object of the investigation described in this paper was to study further the influence of stress range and cycle frequency on corrosion. For this purpose some alloys not studied previously were included.

The method of experiment was that described in previous papers. Each experiment was in two stages. In the first stage each specimen was subjected to cyclic stress while in contact with water; and in the second the specimen, after being oiled, was subjected to fatigue test at 1450 r.p.m. in air. The methods of test are discussed in some detail and the results explained with the aid of net-damage diagrams.

Lubricant Testing. E. G. Boden and O. L. Maag. Paper presented at the lubrication-engineering meeting of the Fifth Oil-Power Conference, State College, Pa., May 22, 1931. [G-1]

A simple machine developed for testing the power of lubricants to withstand high unit pressures with high rubbing speeds is described. The results of these tests are shown in photographs of test blocks that reveal the effect of pressure and speed when using oils of various viscosities and composition.

In conclusion, the authors advocate the development of standard apparatus for determining the carrying capacity of lubricants to be used for gearing in general and particularly for high unit loading.

A lubricant made for this type of service should have at least the following characteristics:

(*Continued on next left-hand page*)

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Notes and Reviews

Continued

(1) Freedom from separation when standing and in service
(2) Minimum of abrasive action
(3) Ability to carry certain specific loads at definite rubbing speeds
(4) Freedom from channeling at low temperatures
(5) Be reasonably cheap and conveniently obtainable
(6) Shall not produce etching or discoloration of bearings and the like.

Symposium on Aircraft Materials. Given at the 33rd annual meeting of the American Society for Testing Materials, Atlantic City, N. J., June 23 to 27, 1930. Published as a reprint from the *Proceedings of the American Society for Testing Materials*, Philadelphia; vol. 30, part II, 1930; 192 pp., illustrated. **[G-1]**

In his introduction to this volume Horace C. Knerr points cut that perhaps in no industry is an exact knowledge of the properties of materials of construction more necessary than in the aircraft industry. Each individual part must be completely dependable and yet must be reduced to the lowest possible weight. Factors of safety must be ample. It is essential to know just what service each type and class of material can be depended upon to render and to assure that each unit and element will perform at par. This calls for accurate and complete engineering data, adequate and standardized specifications, and rigorous and thorough testing to assure that requirements are met.

The symposium was dedicated to this need. In view of the limitations of space available for publication, the consensus of opinion was that it might best take the form of a group of papers each dealing with some topic of major importance in connection with aircraft materials and that these papers be in the nature of comprehensive but condensed digests and summaries rather than dealing with new or specialized developments in the art. Furthermore, it was intended that the papers be devoted to materials and testing problems rather than to design features. Seventeen papers are included.

Die Verwendung von Spiritus als Treibstoff in Deutschland. By K. R. Dietrich. Published in *Automobiltechnische Zeitschrift*, March 31, p. 209, and April 10, 1931, p. 234. **[G-1]**

A struggle of more than 30 years to popularize the use of alcohol or alcohol blends as engine fuel in Germany is summarized in this article. Technical, economic and administrative aspects of the subject are covered.

Inability to produce alcohol free of water content, which was one of the final obstacles to the use of an alcohol fuel, was solved a few years ago by the perfection of manufacturing methods, asserts the author, who states that the motorist can now use alcohol in his engine interchangeably with other fuels, obtain favorable fuel consumption even with customary compression-ratios provided the carbureter is adjusted correctly, and need have no fear of corrosion. These conditions are reflected in a 60-per cent increase in the sale of alcohol for engine-fuel purposes in 1929 as compared with 1928.

L'Utilisation des Huiles Végétales sans le Moteur Diesel. By Marcel Gauthier. Published in *La Technique Moderne*, April 15, 1931, p. 251. **[G-1]**

In this article the author describes one of the many efforts put forth by France in her aim to develop a national fuel source and describes experiments made to ascertain whether vegetable oils can be substituted for heavy petroleum fuel in Diesel engines.

Two four-stroke-cycle M.A.N. Diesel engines were used in the tests, one a six-cylinder, developing 300 hp. at 390 r.p.m., and the other a two-cylinder, developing 660 hp. at

(*Continued on next left-hand page*)

On the job

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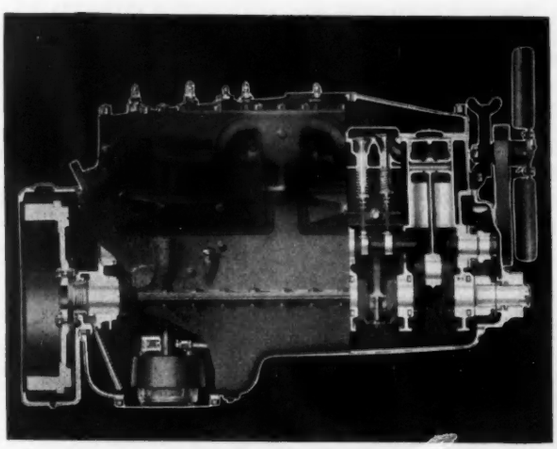

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14

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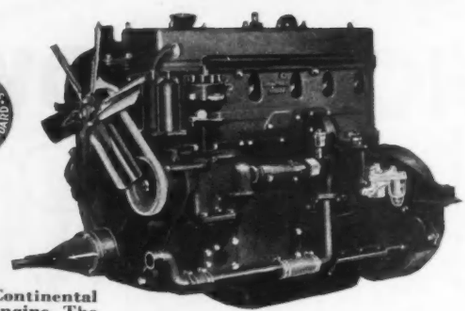

• Side view of Continental "R" 6 cylinder engine. The "R" overhead-valve series range from 73 to 100 horsepower.

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Continental Engines

Notes and Reviews

Continued

the same speed. The engines were operated successively on four types of vegetable oil and then, for purposes of comparison, on gas-oil.

The conclusion drawn from the test is that vegetable oils are an excellent fuel for Diesel engines of the régime tested. Their use necessitates no change in the compression ratio, but only an easily made adjustment in the fuel-valve timing during the starting period. Starting is said to be smooth, operation regular, the brake thermal efficiency and specific fuel consumption of the same order or slightly better than obtained with gas-oil, and the fouling of the combustion-chamber virtually unnoticeable.

The economic problem involved in the production of vegetable oils will be solved, in the opinion of the author, by encouragement of this industry in France's colonial empire.

Iron-Silicon Alloys Bibliography. Compiled, classified and annotated by the Iron Alloys Committee and Earl S. Greiner. Published by The Engineering Foundation, New York City, 1931; 347 pp. [G-3]

This bibliography of the iron-silicon alloys is a by-product of an attempt to survey completely the world's literature on alloy systems in which iron is the principal component. Excepting some references in the historical section, every article and paper has been critically reviewed by the editorial staff and abstracted in as much detail as its importance warranted.

The classic textbook by Henry Marion Howe, The Metallurgy of Steel, edition 2, 1891, was used as a date-line, on the assumption that it is a good summary of all important work before 1890. The present bibliography covers the period from 1890 to 1930.

The S.A.E. is represented on the Iron Alloys Committee of the Engineering Foundation under whose auspices this bibliography was prepared as part of a comprehension program of research in this field.

A List of Alloys with Physical Properties of Typical Alloys. Prepared by William Campbell. Published by the American Society for Testing Materials, Philadelphia, revised and amplified, 1930; 65 pp. [G-3]

In connection with the activities in the nomenclature of non-ferrous metals and alloys of Committee B-2 on Non-Ferrous Metals and Alloys of the American Society for Testing Materials, this list was compiled to show the difficulties that are met when an attempt is made to formulate a logical and scientific classification of alloys.

The list is primarily one of non-ferrous alloys, but to it have been added a few examples of what are, correctly, iron alloys, in contradistinction to steel, in which the properties are dependent on the added elements, as, for example, in the list of non-corrosive alloys and of the heat-resisting alloys as well as those used for resistance purposes.

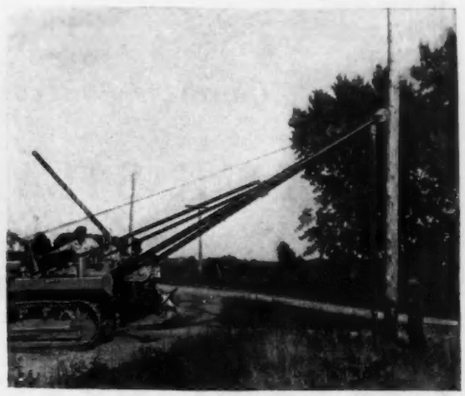
Materials Handbook. By George S. Brady. Published by the McGraw-Hill Book Co., New York City and London; second edition, 1931; 588 pp. Price $5. [G-3]

The second edition of this encyclopedia of distinguishing data on raw materials has been prepared, the author states, with special attention to the needs of the product engineer, yet without departing from the original intention to give the purchasing agent and the industrial executive quick reference data that will aid them in selecting materials. The items relating to engineering construction materials have been extended to include enough comparative data on the physical properties to enable the designing engineer to

(*Continued on page* 48)

Strong, Tough Gears and Pinions of Vanadium Steel Insure Dependability

Of This Hole Borer and Pole Setter



HIGHWAY Earth Boring Machines and Pole Setters, built by Highway Trailer Company, Edgerton, Wisconsin, are often called upon to work in gravel and stony soils. Stones and other obstructions can seldom be avoided, for their presence is usually unknown until the boring augur strikes them. Obviously, the sudden impact exerts severe shock and strain through the machine and its auxiliary transmission, particularly upon gears and pinions.

To meet these severe conditions, Highway Trailer Company sought a gear steel of high strength and durability—a steel that would provide high surface-hardness and a tough core. The compact design of the machine and auxiliary transmission limited the available gear space, thus adding to the complexity of the problem.

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Notes and Reviews

Continued

judge the relative merits of the particular material for the specific requirement. New materials have also been added.

Narrow Operating Temperature Range Improves Lubricant Performance. By H. C. Mougey. Published in *National Petroleum News*, March 11, 1931, p. 32-D. **[G-4]**

This article is a consideration of those characteristics of lubricants that affect engine performance. The author shows in chart from the results of tests to determine the effect of both minimum and maximum viscosity on oil consumption and on cold starting. Mr. Mougey stresses the importance of having the oil suited to the engine and the operating conditions. He points out that this has been recognized in the general use of the S.A.E. viscosity numbers.

The effect of oil-coolers is discussed at some length, and transmission lubrication is considered.

In conclusion the author explains that he has paid little attention to such tests as gravity, flash, fire, color, emulsion, oxidation and so forth because, unless these tests are related to performance in service, their principal use is for purposes of identification or for controlling refining operations.

By the use of S.A.E. viscosity numbers, a car owner can request, and the filling station attendant can furnish, oil of the correct viscosity and consistency. The quality of the lubricant, so far as other factors are concerned, depends upon the integrity and ability of the oil company supplying the lubricant.

Welding Processes Applicable to Aluminum. By W. M. Dunlap. Paper presented at the symposium on welding at the Pittsburgh regional meeting of the American Society for Testing Materials, March 18, 1931. **[G-5]**

Herein the author outlines briefly the methods of welding that are applicable to aluminum and describes the circumstances under which each method can be applied most successfully.

Other papers in the symposium of particular interest to the automotive industry are:

Fatigue and Impact Testing of Welded Products, by T. M. Jasper, and Tests of Welding Made by the Watertown Arsenal, by G. F. Jenks. Preprints of the latter are not available.

MISCELLANEOUS

Standards Yearbook, 1931. Compiled by the Bureau of Standards. Published by the Department of Commerce, City of Washington; fifth issue, 1931; 399 pp. including index. Price, $1. **[H-3]**

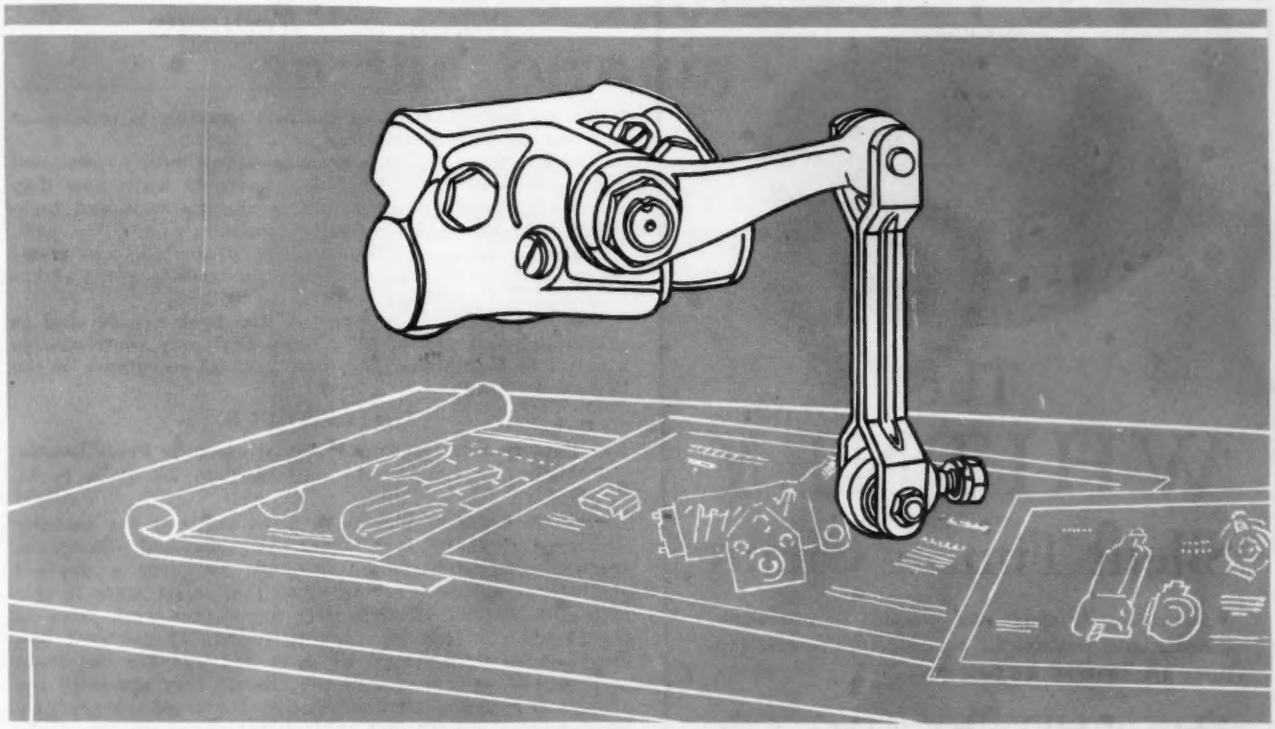
In this publication is presented a picture of the standardization movement in various fields of industry conducted by certain national and international agencies. Among the special features is a series of articles contributed by experts in the several fields of transport. These are intended to give a panoramic view of the value of research as an aid to standardization together with brief summaries of the accomplishments in the respective fields covered.

Also included in this issue is a bibliography of recent publications relating to standardization, contributed by courtesy of the Library of Congress.

Quantity and Economy in Manufacture. By Fairfield E. Raymond. Published by the McGraw-Hill Book Co., Inc., New York City and London, 1931; 375 pp., illustrated. Price, $4. **[H-5]**

The author, who is assistant professor of industrial research at the Massachusetts Institute of Technology, contends that the subject of economic lot sizes strikes to the very roots of the effective operation of a manufacturing plant, and that some consideration of the principles under-

(*Concluded on next left-hand page*)



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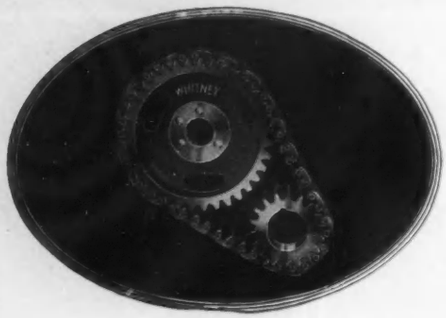

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Notes and Reviews

Concluded

lying the determination of the best quantity to produce at any one time is essential.

The first three chapters are intended primarily to interest the higher executives who may desire to learn how they or their enterprise can profit by the methods and technique described in the remaining chapters of the first part. Calculation sheets and graphs are presented, mechanical means of solution suggested, and illustrations given of the way in which each can properly be utilized.

The second and third parts of the book are devoted to a thorough analysis of all factors that may contribute to a better understanding and more general acceptance of the basic principles.

MOTOR-TRUCK

Une Evolution du Bandage Pneumatique pour Poids Lourds. Published in *La Vie Automobile*, Jan. 25, 1931, p. 33. [K-1]

The low-pressure pneumatic tires used on the recently developed Chenard & Walcker, Lagache and Glaszmann tractor-trailer combination designed to carry a payload of 25 tons represent, according to the claims made in this article, a distinct advance over any motor-truck tires so far exploited. They are said to require 30 per cent less air pressure than American tires designed for the same purpose and to transmit to the chassis only one-third the amount of road shock transmitted by the usual low-pressure tires and one-seventh that transmitted by the old-type high-pressure tires. Better traction, less skidding, more effective braking and higher average speed due to the lack of tire overheating are advantages claimed to be attendant on the use of the large-size balloons.

PASSENGER CAR

Psychological Principles in Automotive Driving. By Albert P. Weiss and Alvah R. Lauer. Graduate School Series No. 11. Published under the auspices of the National Research Council by the Ohio State University, Columbus, Ohio, 1930; 165 pp., illustrated. Price, $1.50. [L-4]

The undertaking reported in this pamphlet set out to secure fundamental information on the psychological aspects of automotive driving which could be used as a basis by the Federal Government for formulating a model set of statutes for licensing drivers of motor-vehicles.

During the first year, motor-coordination apparatus was constructed which reproduced and recorded under laboratory conditions the essential movements (eye, hand, foot coordination) used in driving a car. A program of experimentation differentiating the general problem into factors that could be separately brought under experimental conditions was developed. Cooperation was successfully sought with political, governmental and industrial units.

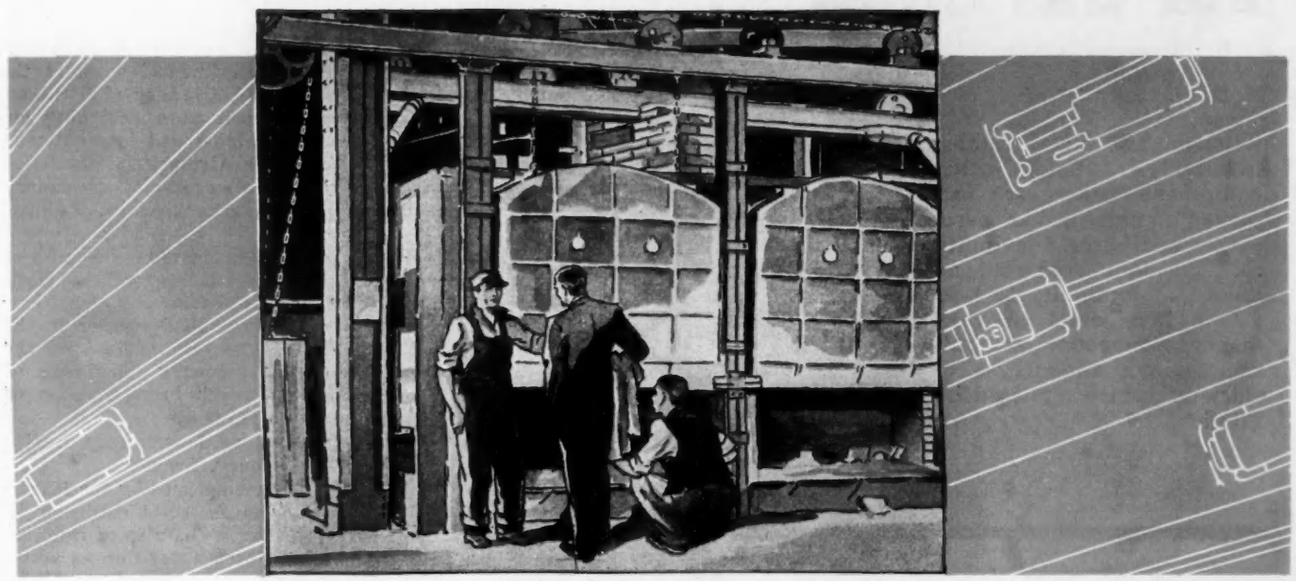
The authors point out that, since it is impossible to eliminate accidents completely and at the same time increase the flow of traffic indefinitely, the problem from the social and economic standpoint becomes that of finding the optimum relation between safety and increased traffic. Therefore the major problem was to determine the individual differences between different classes of drivers. Among the numerous secondary problems that arose were: (*a*) the effect of visual and sensory disturbances; (*b*) muscular coordination and allied phenomena; (*c*) nervousness and emotional disturbances; (*d*) the development of special muscular habits, postures and social responses to other operators and pedestrians.

Mechanical factors that modify the driver's movements include the optimal positions of road signs and signal lights and the effect of billboards and lateral visual obstructions. Among the factors affecting the personal equation of the driver are drugs, loss of sleep, and the social, economic and intellectual status.

The papers which appear in this monograph constitute a preliminary report of these studies. The apparatus is described in detail and the results are summarized.

The hard spots were in the furnace . . . . .

NOT IN THE STEEL



AGAIN came the cry of "hard spots in the steel"...this time from a forge company noted for the quality of its production for the automotive field.

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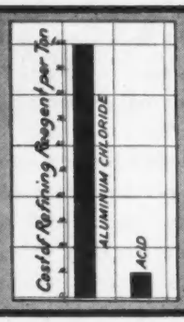

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Personal Notes of the Members

(Continued from p. 102)

ously had charge of development and research for the Universal Oil Products Co., in the research laboratories at Riverside, Ill.

William V. Foster has been employed by the Duplex Printing Press Co., of Battle Creek, Mich., as a junior engineer. He was previously engaged in experimental work in the engineering shop department of the University of Michigan.

Harry L. Gibson is now employed as a designing engineer in charge of aircraft and high-speed internal-combustion engine design for the Miller Airplane Products Co., of Los Angeles. He formerly was a member of the experimental department of the National Parks Airways, of Butte, Mont.

James E. Glidewell has been promoted from the post of engineer to that of assistant chief engineer of the Hall-Scott Motor Car Co., of Berkeley, Calif.

Ralph G. Graham has been made chief inspector in the airplane division of the South Bend, Ind., plant of the Bendix Aviation Corp. He was formerly in charge of the gear laboratory for the Muncie Products Division of the General Motors Corp., at Muncie, Ind.

Carl Gustafson is now employed as a designing draftsman with A. Bol Volvo, of Gothenburg, Sweden.

Edward Hector, who was formerly employed by the Houde Engineering Corp., of Buffalo, as an assistant engineer, is now an engineer for the J. H. Williams Co., also of Buffalo.

Harold D. Hoekstra recently accepted a position as aeronautic engineer with the Ford Motor Co., of Dearborn, Mich. Prior to making this connection he was chief airplane engineer for the Crosby Aircraft Co., of Sharonville, Ohio.

Having relinquished his post as a designer for the Sikorsky Aviation Corp., of Bridgeport, Conn., **O. Holm-Hansen** is now working on his own patents.

S. S. Jenkins was recently appointed regional director for the Reo Motor Car Co., of Lansing, Mich., having left his former post as sales engineer for the Chrysler Export Corp., of Detroit.

Clarence Wesley Miller is now serving the Wilcox-Rich Corp. as vice-president and general manager. His previous connection was with the Thompson Products, Inc., of Cleveland, of which he was vice-president.

Wallace T. Miller has been appointed assistant general sales manager for the Motor Wheel Corp., of Lansing, Mich. He previously was a sales engineer for the Lundelius & Eccleston Motors Corp., of Los Angeles.

F. L. Ortla is now chief engineer of the New England Automatic Coal Burner Corp., of Boston.

R. S. Perry is now associated with the Ingersoll Milling Machine Co., of Rockford, Ill., as vice-president. He recently terminated his connection with the Hudson Motor Car Co., of Detroit, as planning manager.

George F. Piroomoff, formerly techical assistant to the president of the Brockway Motor Truck Corp., of Cortland, N. Y., was elected vice-president in charge of engineering at a meeting of the new board of directors following the recent postponement of the annual meeting of the corporation.

Seth B. Robinson, Jr., has been appointed assistant to the manager of the New England district for the White Co., of Boston, having been transferred from his post as office manager of the company branch in Long Island City, N. Y.

W. W. Rogers has formed a new connection as Michigan representative and sales engineer for the Speer Carbon Co., of Saint Marys, Pa. He formerly filled a similar position with the Bound Brook Bearing Co., of Bound Brook, N. J.

G. A. Schreiber, consulting engineer, whose European office is now affiliated with the firm of Koch & Kienzle, of Berlin, Germany, has returned to America and will occupy his offices in Detroit until November of this year.

Alexander Senowski recently accepted the post of technical director of the Institute of Aeronautical Researches,

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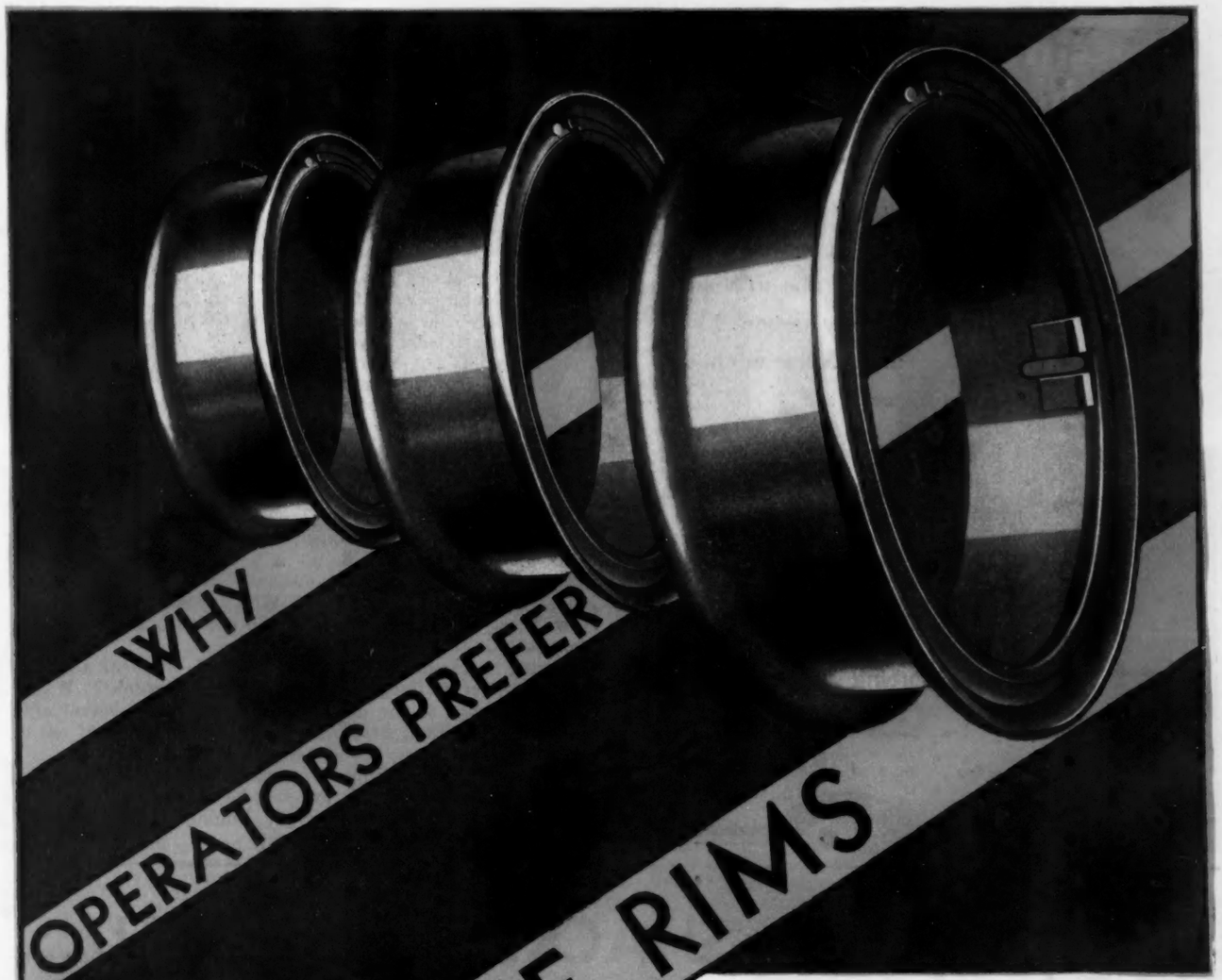

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Personal Notes of the Members

Concluded

of Warsaw, Poland. Before forming this new connection he was assistant manager and aviation engineer for the Polis Skoda Works, also of Warsaw.

R. V. Shafer has opened the Emerald City Service Station, at Redwood City, Calif. He previously served the Harnischfeger Sales Corp., of San Francisco, as Diesel service engineer.

W. G. Sternberg has been elected vice-president of the Sterling Motor Truck Co. of California, at Los Angeles. He formerly was president of the Sterling Motor Truck Co., of Long Island City, N. Y.

Information has been received to the effect that **Morton C. Swift** is now connected with the general laboratory of the Standard Oil Co. of New York, at Brooklyn, N. Y., as automotive engineer. Previously he was test engineer for the Pratt & Whitney Aircraft Co., at East Hartford, Conn.

Stanley J. Swift was recently appointed Toledo district sales representative for the Russell Mfg. Co., of Middletown, Conn. He served the Cleveland Pneumatic Tool Co., of Cleveland, in a similar capacity prior to making this new connection.

James M. Talbot has been promoted from manager of the industrial division of the S. S. White Dental Mfg. Co., of New York City, to manager of the company's Prince Bay plant on Staten Island, N. Y.

Having relinquished his post as chief engineer for the Alliance Aircraft Corp., of Alliance, Ohio, **Gordon T. Waite** is now attached to the office of the inspector of Naval aircraft, of the United States Navy, in the capacity of aeronautic engineer.

Carlton H. Wolf is now employed by the Kellett Aircraft Corp., of Philadelphia. Previously he was aeronautic engineer with the National Aircraft Engineers, Inc., of the City of Washington.

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